Change of the Decorative Properties of Zinc-Plated Zinc Die Castings over Time

Zinc alloy die casting is often chosen for the manufacturing of various consumer goods, since this process allows manufacturing of parts with a consistent quality and a high cost efficiency. With regard to recycling, using zinc electrodeposition as a surface treatment for zinc die cast offers clear advantages. However, it is often noticed that bright zinc-plated coatings on zinc die cast components change color over time, developing distinct blue spots on the surface. In the present study, zinc-plated zinc die cast components were aged and characterized via Energy-Dispersive X-ray Spectroscopy, X-ray diffraction, and gloss and color analyses to make a conclusion on the mechanism of tarnishing. It was found that over time aluminum from the substrate diffuses through the coating, with the different diffusion rates for the coatings that were deposited from the different electrolyte types. Thus, alkaline zinc showed higher rates of aluminum diffusion compared to acid zinc. It was speculated that aluminum diffusion through the coating followed by oxidation under the influence of ambient moisture and contaminants triggers the observed blue discoloration.
Electrodeposition of Iron with Co-deposition of Carbon: On the Nature of Nanocrystalline Fe-C Coatings

Fe-C coatings were electrodeposited from an iron-sulfate electrolyte containing citric acid as a carbon source. Differently thick coatings were deposited onto amorphous substrates, which allows substrate-unbiased nucleation and thereby enables the study of the intrinsic growth of Fe-C coatings. The internal structure of the Fe-C coating was systematically investigated applying complementary methods of materials characterization using microscopy, spectroscopy, and X-ray diffraction analysis, which was further supplemented with microhardness measurements. For the measured high carbon concentration of more than 0.8 wt pct, the experimental results indicate the formation of Fe2C carbides. Together with the nanocrystalline carbon-free ferrite grains with strong 311 fiber texture, the carbides provide a very high microhardness of almost 800 HV, as measured for the Fe-C coatings independent of the coating thickness. The results essentially contribute to understanding of the growth characteristics and phase formation during electrodeposition of the Fe-C coatings, which is needed for their industrial applications as hard coatings.

Influence of chlorides and phosphates on the antiadhesive, antibacterial, and electrochemical properties of an electroplated copper-silver alloy

Antimicrobial surfaces such as copper alloys can reduce the spread of pathogenic microorganisms, e.g., in healthcare settings; however, the surface chemistry and thus the antibacterial activity are influenced by environmental parameters such as cleaning and disinfection procedures. Therefore, the purpose of the present study was to assess how copper-complexing compounds (chlorides and phosphates), common to the clinical environment, can affect the surface chemistry and the antiadhesive and antibacterial properties of a newly developed antibacterial copper-silver alloy and the single alloying metals. The authors demonstrated that the antiadhesion efficacy against S. aureus 8325 was the highest when the copper-silver alloy and copper surfaces (four- and two-log bacterial reduction compared to stainless steel controls, respectively) were exposed to chloride-containing suspensions. This was explained by the electrochemical activity of copper that dissolved as Cu+, highly toxic to the bacterial cells, in the presence of Cl- and eventually formed a chlorine- and oxygen-rich layer with the incorporation of phosphorus, if also phosphates were present. If chlorides were omitted from the wet environment, there was no difference (P > 0.05) in bacterial counts on copper-silver alloy, copper, silver, and AISI 316 stainless steel control surfaces, due to the fact that no oxidizing conditions were established and therefore there was no dissolution of copper ions from copper-silver alloy and copper surfaces. However, under dry conditions, copper-silver alloy and pure copper surfaces were antibacterial also in the absence of chlorides, suggesting a marked difference between dry and wet conditions in terms of the interactions between surfaces and bacteria. The authors conclude that an attentive design of control policies integrating disinfection interventions and antimicrobial surfaces, such as the copper-silver alloy coating, can be a beneficial solution in fighting the spread of antibiotic resistant bacterial strains and potentially reducing the number of disease outbreaks.
Investigation of High pH Corrosion under Alternating Current Interference
This paper investigates the possible alternating current (AC) corrosion mechanism as dihypoferrite dissolution at high pH under an alternating voltage perturbation and compares polarization behavior of three commonly used pipeline steels, X52, X65, and X70. The methods used are polarization scans at various interference levels, weight-loss coupons, and ER-probe corrosion rate measurements. It is found that AC enhances the stability region of dihypoferrite in the Pourbaix diagram, leading to corrosive conditions for all investigated steels, but that within the investigated steel types, the alloy is of less importance. A mechanistic model for AC corrosion that considers a soluble ion and the role of hydrogen evolution is presented.

The Potential of Biogas; The Solution to Energy Storage
Energy storage will be a demand for balancing the renewable energy systems of tomorrow - especially when excess electricity from wind and solar power requires immediate utilization. Using biogas as a carbon source can generate CO₂-neutral carbon-based energy carriers, such as methane or methanol. Utilization of biogas today is limited to the generation of heat and power or biomethane (first generation upgrading), both processes disregarding the potential of the large amount of co-produced CO₂ during the fermentation process. Using renewable energy, biogas upgrading systems can convert the carbon dioxide into hydrocarbon-based high-density energy fuels which can replace fossil-based fuels for applications where they are hard to decarbonize. In this perspective, the authors argue for future utilization possibilities of biogas and introduce the terminology of second generation upgrading to help research and development within this field.
We believe that second generation upgrading of biogas will have a huge potential for dynamic energy storage.

**An electroplated copper–silver alloy as antibacterial coating on stainless steel**

Transfer and growth of pathogenic microorganisms must be prevented in many areas such as the clinical sector. One element of transfer is the adhesion of pathogens to different surfaces and the purpose of the present study was to develop and investigate the antibacterial efficacy of stainless steel electroplated with a copper-silver alloy with the aim of developing antibacterial surfaces for the medical and health care sector. The microstructural characterization showed a porous microstructure of electroplated copper-silver coating and a homogeneous alloy with presence of interstitial silver. The copper-silver alloy coating showed active corrosion behavior in chloride-containing environments. ICP-MS measurements revealed a selective and localized dissolution of copper ions in wet conditions due to its galvanic coupling with silver. No live bacteria adhered to the copper-silver surfaces when exposed to suspensions of S. aureus and E. coli at a level of $10^5$CFU/ml whereas $10^4$CFU/cm² adhered after 24h on the stainless steel controls. In addition, the Cu-Ag alloy caused a significant reduction of bacteria in the suspensions. The coating was superior in its antibacterial activity as compared to pure copper and silver electroplated surfaces. Therefore, the results showed that the electroplated copper-silver coating represents an effective and potentially economically feasible way of limiting surface spreading of pathogens.
False-positive result when a diphenylcarbazide spot test is used on trivalent chromium-passivated zinc surfaces
A colorimetric 1,5-diphenylcarbazide (DPC)-based spot test can be used to identify hexavalent chromium on various metallic and leather surfaces. DPC testing on trivalent chromium-passivated zinc surfaces has unexpectedly given positive results in some cases, apparently indicating the presence of hexavalent chromium; however, the presence of hexavalent chromium has never been confirmed with more sensitive and accurate test methods.

Objectives
To examine the presence of hexavalent chromium on trivalent chromium-passivated zinc surfaces with a DPC-based spot test.

Methods
A colorimetric DPC spot test was used for the initial detection of hexavalent chromium on new and 1-year-aged trivalent chromium-passivated zinc surfaces. Then, X-ray photoelectron spectroscopy (XPS) was performed for all samples.

Results
The DPC spot test indicated the presence of hexavalent chromium in aged, but not new, trivalent chromium passivation on zinc; however, subsequent analysis by XPS could not confirm the presence of chromium in a hexavalent state.

Conclusions
Unintended oxidation of DPC induced by atmospheric corrosion is suggested as a possible reason for the false-positive reaction of the DPC test on a trivalent chromium-passivated zinc surface. Further validation of the use of the DPC test for chromium-containing metallic surfaces is required.

Investigation of stone-hard-soil formation from AC corrosion of cathodically protected pipeline
A stone-hard-soil structure was observed on a metallic pipeline under cathodic protection and subject to alternating current corrosion at a coating defect. Using X-ray diffraction, energy dispersive X-ray spectroscopy, ion-chromatography and inductively coupled plasma optical emission spectroscopy, the stone-hard-soil was characterized as being enriched in
NaCl. Local alkalization following the cathode reactions caused precipitation of calcite, believed to be partly responsible for the stability of the structure. Very close to the corrosion site at the epicenter, calcite and quartz was depleted, possibly owing to an extremely high pH. Formation of cement-like minerals and corrosion products is observed.

**General information**
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Department of Civil Engineering, DEFSA SA, MetriCorr ApS
Contributors: Junker, A., Belmonte, L. J., Kioupis, N., Nielsen, L. V., Møller, P.
Pages: 1170-1179
Publication date: 2018
Peer-reviewed: Yes

**Publication information**
Journal: Materials and Corrosion
Volume: 69
Issue number: 9
ISSN (Print): 0947-5117
Ratings: BFI (2018): BFI-level 1
Scopus rating (2018): CiteScore 1.51 SJR 0.516 SNIP 0.79
Web of Science (2018): Impact factor 1.458
Web of Science (2018): Indexed yes
Original language: English
Keywords: Alternating current (AC), Calcareous deposition, Carbon steel, Cathodic protection, Pipeline, X-ray diffraction

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Hydrogen silsesquioxane (HSiO3/2)n based “spin-on-glass” has been deposited on 316L substrate and cured in Ar/H2 gas atmosphere at 600 °C to form a continuous surface coating with sub-micrometer thickness. The coating functionality depends primarily on the adhesion to the substrate, which is largely affected by the chemical interaction at the interface between the coating and the substrate. We have investigated this interface by transmission electron microscopy and electron energy loss spectroscopy. The analysis identified a 5-10 nm thick interaction zone containing signals from O, Si, Cr and Fe. Analysis of the energy loss near edge structure of the present elements identified predominantly signal from [SiO4]4- units together with Fe2+, Cr2+ and traces of Cr3+. High-resolution transmission electron microscopy images of the interface region confirm a crystalline Fe2SiO4 interfacial region. In agreement with computational thermodynamics, it is proposed that the spin-on-glass forms a chemically bonded silicate-rich interaction zone with the substrate. It was further suggested that this zone is composed of a corundum-type oxide at the substrate surface, followed by an olivine-structure intermediate phase and a spinel-type oxide in the outer regions of the interfacial zone.

**General information**
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Center for Electron Nanoscopy, DTU Danchip, SiOx ApS
Contributors: Lampert, F., Kadkhodazadeh, S., Kasama, T., Dahl, K. V., Christiansen, A. B., Møller, P.
Pages: 3170-3176
Publication date: 2018
Peer-reviewed: Yes

**Publication information**
Journal: Langmuir
Volume: 34
Issue number: 10
ISSN (Print): 0743-7463
Ratings: BFI (2018): BFI-level 1
Properties and performance of spin-on-glass coatings for the corrosion protection of stainless steels in chloride media

Spin-on-glass deposition was investigated as viable alternative to increase the durability and performance of 316L steel in chloride environment. The buildup of a detrimental interface oxide was prevented by non-oxidative thermal curing of the coatings, which leads to a transformation to an inorganic, SiO₂-like material. The degree of polymerization was found dependent on the curing temperature; however, even curing at the maximum investigated curing temperature of 800°C led to still incomplete transformation, showing less SiO₂-like character with respect to thermally grown oxide or fused silica. Electrochemical analysis by cyclic polarization indicated that the coatings behave as imperfect barrier coatings, which may enhance the passive properties of the substrates; however, there is still some statistical scatter in the quality of the coatings. While there is a tendency for an increase of the upper limit of the breakdown potential, there is also a decrease of the lower limit. It was found that such lower quality coatings showed, in association with substrate defects, unevenly distributed coating flaws, which may act as initiation points of pitting corrosion and decrease the corrosion resistance of coated substrates. Further, the films showed instability in aqueous environment due to imperfect polymerization.

Surface technology is essential for transition to a hydrogen-based energy system

The importance of advanced surface technology for the success of the ongoing energy turnaround in Germany has recently been discussed in this journal. The purpose of the present article is to add views based on the conditions valid for the Nordic region.
Systems and methods for modifying surfaces of substrates

The present disclosure presents a method and a system for modifying a surface of a substrate. The method includes an act of abrasive blasting of a part of the surface of the substrate. In the abrasive blasting, an abrasive media is provided to the part of the surface. The abrasive media is carried to the part by a first carrier. The abrasive media collides with the part of the surface and causes abrasion to the part of the surface. In the method, the first carrier includes steam. The steam of the first carrier heats the part of the surface.

Corrosion Resistance of AISI 316L Coated with an Air-Cured Hydrogen Silsesquioxane Based Spin-On-Glass Enamel in Chloride Environment

The efficiency of thin hydrogen silsesquioxane (HSQ) -based corrosion barrier coatings on 316 Lsubstrates after oxidative thermal curing at 400-550 °C in air was investigated. Infrared spectroscopy and electrochemical impedance spectroscopy showed that an increasing curing temperature leads to progressing coating densification, accompanied by decreasing barrier properties. Cyclic polarization measurements indicated that defects due to substrate oxidation are detrimental for the substrate passivity. Insufficiently polymerized coatings showed poor chemical stability in neutral salt spray testing and the chemical coating stability increased with curing temperature. Oxidative curing was found inadequate as polymerization treatment of HSQ-based corrosion barrier coatings on 316L substrate.
Effect of Chemical Environment and pH on AC Corrosion of Cathodically Protected Structures

AC corrosion of structures under cathodic protection (CP) is a major concern for pipelines in case of even minor AC perturbations. There are indications that the specific chemical environment has a large influence on the AC mitigation current density criteria outlined in EN 15280:2013 [1]. This work investigates the effect of soil constituents, the earth alkali elements Ca and Mg, believed to have a large influence on the precipitation of hydroxides and carbonates in front of a coating damage. The formation of different polymorphous calcium carbonates, depending on the cathodic potential are observed as well as calcium hydroxides at high cathodic protection levels. This indicates a highly alkaline (pH > 11) environment locally. Corrosion rates at different cathodic potentials are measured using electrical resistance (ER) probes and a chemical and phase analysis of the calcareous deposits and corrosion products is made using scanning electron microscopy and energy dispersive x-ray spectroscopy (SEM/EDS) and x-ray diffraction (XRD). The findings suggest an AC corrosion mechanism highly dependent on the build-up and break-down of calcareous deposits at high CP, which is clearly reflected in variations in the spread resistance.

Interfacial Interaction of Oxidatively Cured Hydrogen Silsesquioxane Spin-On-Glass Enamel with Stainless Steel Substrate

Thin film silica coatings have proven to be efficient barrier coatings to protect stainless steels from corrosion in aggressive environments. The deposition of sub-μm silica films from liquid hydrogen silsesquioxane precursor has previously been demonstrated on metallic substrates, whereby the films were thermally cured in inert atmosphere, which required complicated processing equipment, such as gas or vacuum furnaces. In contrast, curing in air is a promising routine to simplify the curing process, reduce curing cost and increase the curing efficiency. In the present work, silica-like thin films were deposited on 316L grade austenitic stainless steel and oxidatively cured at 450◦C in ambient air. Oxidative curing yielded well adherent films which solely showed microscopic delamination after standardized adherence testing. Further, the oxidative curing led to the formation of a pronounced interfacial duplex-oxide with an outer zone composed of Fe₂O₃ in a SiO₂₋ₓ matrix and an inner zone composed of complex (Cr³⁺, Fe²⁺, Mn²⁺)-oxides. Moreover, a Cr depletion of the substrate in the immediate vicinity of the surface was observed. It was concluded that the interfacial formation is controlled by the kinetic limitation of Cr transport to the interface, which consequently led to the Cr-depletion of the sub-surface.
Nickel-aluminum diffusion: A study of evolution of microstructure and phase

Microstructural and phase evolution of an aluminum deposit on nickel, after heat treatment at 883 K, is studied by means of various microscopy techniques, i.e. energy dispersive X-ray spectroscopy, backscattered electron imaging, electron backscatter diffraction, ion channeling contrast imaging and scanning transmission electron microscopy. AlNi₃ crystallites are observed on the aluminum grain boundaries after only 3 min of heat treatment indicating that nickel and nickel rich phases are the initially diffusing and forming species. Heat treatment for 120 min or longer results in the formation of Al₃Ni₂ and a porous Al₃Ni₂/γ-Al₂O₃ structure at the surface. The Al₃Ni₂ layer is composed of two different grain morphologies, indicating the position of a Kirkendall plane, and hence, there is a high diffusion rate of aluminum in this phase.
Hydrogen Silsesquioxane based silica glass coatings for the corrosion protection of austenitic stainless steel

The application of stainless steels in hostile environments, such as concentrated acid or hot sea water, requires additional surface treatments, considering that the native surface oxide does not guarantee sufficient corrosion protection under these conditions. In the present work, silica-like thin-film barrier coatings were deposited on AISI 316L grade austenitic stainless steel with 2B surface finish from Hydrogen Silsesquioxane (HSQ) spin-on-glass precursor and thermally cured to tailor the film properties. Results showed that curing at 500 °C resulted in a film-structure with a polymerized siloxane backbone and a reduced amount of Si-H moieties. The coatings showed good substrate coverage and the average thickness was between 200 and 400 nm on the rough substrate surface, however, film thicknesses of > 1400 nm were observed at substrate defects. Deposition of these films significantly improved the barrier-properties by showing a 1000 times higher modulus while an ionic transport over the coating was also observed.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, SiOx ApS
Contributors: Lampert, F., Jensen, A. H., Din, R. U., Møller, P.
Number of pages: 33
Pages: 879–885
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Surface and Coatings Technology
Volume: 307
Issue number: Part A
ISSN (Print): 0257-8972
Ratings:
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.56 SJR 0.882 SNIP 1.379
Web of Science (2016): Impact factor 2.589
Web of Science (2016): Indexed yes
Original language: English
Keywords: Barrier coating, Corrosion, Electrochemical Impedance Spectroscopy, Hydrogen Silsesquioxane, Thin film
Electronic versions: 1_s2.0_S025789721631012X_main.pdf. Embargo ended: 09/10/2018
DOIs:
10.1016/j.surfcoat.2016.10.020
Source: FindIt
Source ID: 2347252442
Research output: Contribution to journal › Journal article – Annual report year: 2016 › Research › peer-review

Low Temperature Curing of Hydrogen Silsesquioxane Surface Coatings for Corrosion Protection of Aluminum

Hydrogen Silsesquioxane (HSQ) has shown to be a promising precursor for corrosion protective glass coatings for metallic substrates due to the excellent barrier properties of the films, especially in the application of protective coatings for aluminum in the automotive industry where high chemical stability in alkaline environments is required. The coatings have been successfully applied to stainless steel substrates. However the traditional thermal curing of HSQ involves heating to elevated temperatures, which are beyond those applicable for most industrial applications of aluminum. In this study low temperature processes are tested and evaluated as possible alternatives to the traditional high temperature cure. Thin HSQ films are deposited on silicon wafers to model the degree of curing induced by the low temperature methods in comparison to thermal curing. Furthermore, the coatings are applied on aluminum substrates to evaluate the adhesion and corrosion resistance of the films.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, SiOx ApS
Contributors: Lampert, F., Jensen, A. H., Møller, P.
Number of pages: 8
Publication date: 2016
Peer-reviewed: Yes
Manufacturing of a LaNiO₃ composite electrode for oxygen evolution in commercial alkaline water electrolysis

The LaNiO₃ perovskite was chosen for incorporation into a nickel matrix in order to obtain a metallic composite electrode suitable for improving the oxygen evolution reaction (OER) in commercial water electrolysis at elevated temperature. The manufactured LaNiO₃ + Ni composite coatings were deposited in a Watts type nickel electrolyte in a specially designed beaker with continuous particle circulation. Activity of the composite coatings was evaluated using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and anodic potentiodynamic polarization measurements. The obtained results were compared to a non-catalysed Watts nickel reference sample and the electrochemical measurements confirmed that the coating decreased the OER overpotential by 70 mV. XRD furthermore revealed that a LaNiO₃ + Ni composite structure was obtained. Conventional alkaline water electrolysis was carried out at a temperature of 120 °C and a current densities of 0.2 and 0.8 A cm⁻². Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS) and X-ray Diffraction (XRD) were used for characterization of the morphology.

Corrosion issues of powder coated AA6060 aluminium profiles

In this study detailed microstructural investigation of the reason for unexpected corrosion of powder coated aluminium alloy AA6060 windows profiles has been performed. The results from this study reveals that the failure of the window profiles was originated from the surface defects present on the extruded AA6060 aluminium profile after metallurgical process prior to powder coating. Surface defects are produced due to intermetallic particles in the alloy, which disturb the flow during the extrusion process. The corrosion mechanism leading to the failure of the powder coated AA6060 aluminium profiles in service is explained.

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Electrical Resistance Measurements and Microstructural Characterization of the Anode/Interconnect Contact in Simulated Anode-Side SOFC Conditions

Metallic interconnects in solid oxide fuel cell (SOFC) stacks are often in direct contact with a nickel/yttria stabilized zirconia (Ni/YSZ) cermet anode. Interdiffusion between the two components may occur at the operating temperature of 700–850 °C. The alteration of chemical composition can result in phase transformation of the steel and in formation of oxides with a poor electrical conductivity in the anode. In this study, the area specific resistance (ASR) of the steel Crofer 22 APU, in contact with a Ni/YSZ anode with and without a tape casted CeO2 barrier layer was measured in simulated SOFC anode conditions at 800 °C. The microstructure in the contact area was characterized using scanning electron microscopy techniques. The ASR was low for the steel in direct contact with the Ni/YSZ anode. Nickel diffusion into the steel resulted in a fine grained zone, which was identified as ferrite. The zone is austenitic at the exposure temperature but transforms to ferrite during cooling. When a CeO2 nickel diffusion barrier layer was used, the ASR was considerably higher. These results imply that nickel diffusion is not only detrimental: It leads to microstructural instability but also results in a low electrical resistance of the anode/interconnect contact.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Center for Electron Nanoscopy, Materials and Surface Engineering, Haldor Topsoe AS
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Pages: 387-396
Publication date: 2015
Peer-reviewed: Yes

Investigations on PVD Al/Ni electrocatalysts for alkaline water electrolysis

Publication information
Journal: Journal of The Electrochemical Society
Volume: 162
Issue number: 4
ISSN (Print): 0013-4651
Ratings:
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.17 SJR 1.115 SNIP 1.064
Web of Science (2015): Impact factor 3.014
Web of Science (2015): Indexed yes
Original language: English
DOIs:
10.1149/2.0381504jes
Source: PublicationPreSubmission
Source ID: 105378568
Research output: Contribution to journal › Journal article – Annual report year: 2015 › Research › peer-review
Oxidation behaviour and electrical properties of cobalt/cerium oxide composite coatings for solid oxide fuel cell interconnects

This work evaluates the performance of cobalt/cerium oxide (Co/CeO2) composite coatings and pure Co coatings to be used for solid oxide fuel cell (SOFC) interconnects. The coatings are electroplated on the ferritic stainless steels Crofer 22 APU and Crofer 22H. Coated and uncoated samples are exposed in air at 800 °C for 3000 h and oxidation rates are measured and oxide scale microstructures are investigated. Area-specific resistances (ASR) in air at 850 °C of coated and uncoated samples are also measured.

A dual layered oxide scale formed on all coated samples. The outer layer consisted of Co, Mn, Fe and Cr oxide and the inner layer consisted of Cr oxide. The CeO2 was present as discrete particles in the outer oxide layer after exposure. The Cr oxide layer thicknesses and oxidations rates were significantly reduced for Co/CeO2 coated samples compared to for Co coated and uncoated samples.

The ASR of all Crofer 22H samples increased significantly faster than of Crofer 22 APU samples which was likely due to the presence of SiO2 in the oxide/metal interface of Crofer 22H.
The effect of surface treatment and topography on corrosion behavior of EN 1.4404 stainless steel: The effect of surface treatment and topography

Corrosion properties of EN 1.4404 (316L) stainless steel with different applied surface treatment, were studied in NaCl solution using cyclic polarization. Observed properties were related to the specific topography of each surface by scanning electron microscopy and cross-section analysis. Average roughness was measured to evaluate the usability for this parameter to be used in assessment of corrosion resistance. Increased surface roughness and the existence of crevices resulted in overall deterioration of corrosion resistance, whereas more smooth and level topographies displayed general improvement. By analyzing the characteristic geometry of the typographies produced, the correlation between the varying corrosion properties and surfaces is determinable. In continuation hereof, the utilization of average roughness values ($R_a$) as an isolated parameter, were found not to be sufficient for the assessment of corrosion resistance. Critical surface geometries with large impact on corrosion properties is not conveyed adequately by $R_a$, and thereby prevents sufficient differentiation between the actual surface properties.

General information
Publication status: Published
Organisations: Department of Management Engineering, Department of Systems Biology, Technical University of Denmark
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Number of pages: 8
Pages: 1060-1067
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Materials and Corrosion
Volume: 66
Issue number: 10
ISSN (Print): 0947-5117
Ratings:
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.53 SJR 0.674 SNIP 1.024
Web of Science (2015): Impact factor 1.45
Web of Science (2015): Indexed yes
Original language: English
Keywords: Average roughness, Pitting corrosion, Repassivation, Stainless steel, Topography
DOIs:
10.1002/maco.201407854
Source: FindIt
Source ID: 2281513977
Research output: Contribution to journal › Journal article – Annual report year: 2015 › Research › peer-review

Allergic chromium dermatitis from wearing 'chromium-free' footwear

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Copenhagen University Hospital
Contributors: Thyssen, J. P., Jellesen, M. S., Möller, P., Menne, T., Johansen, J. D.
Number of pages: 3
Pages: 185-187
Publication date: 2014
Peer-reviewed: Yes

Publication information

Electrochemical investigation of surface area effects on PVD Al-Ni as electrocatalyst for alkaline water electrolysis

A thermo-chemical diffusion of vapour deposited aluminium onto a nickel substrate, leads to a rapid formation of an Al/Ni intermetallic layer that is particularly acceptable for dissolution of aluminium in strong alkali. The geometry and the structure of the final skeletal nickel coatings can be manipulated by altering the time interval of the diffusion. In that way the actual electrochemical surface area and, thus, the electrocatalytic activity of the coatings towards HER and OER can be influenced. Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) investigations, display that the electrocatalytic surface area increases in proportion to the thickness of the developed porous nickel structure. In the case of the HER, an increase in roughness factor (Rf) from 1 (for polished Ni) to 800, results in reduction of the hydrogen overpotential of 337mV. When further increasing Rf, up to above 2000, additional 40mV are gained. For the OER, smaller roughness values were observed with the same activity trend as for the HER. The electrocatalyst are however found not to be stable in the anodic environment during electrolysis. The corrosion mechanism of a skeletal nickel electrocatalyst during the OER in an alkaline environment is briefly discussed. The structure and composition of the electrocatalysts are characterised by scanning electron microscopy and X-ray diffraction. The actual electrocatalytic surface area and the electrocatalytic behaviour are studied with potentiodynamic polarisation, CV and EIS.
Failure of total hip implants: metals and metal release in 52 cases

Background. The pathogenesis of total joint replacement failure is multifactorial. One hypothesis suggests that corrosion and wear of alloys result in metal ion release, which may then cause sensitization and even implant failure, owing to the acquired immune reactivity.

Objectives. To assess cobalt, nickel and chromium(VI) release from, and the metal composition of, failed metal-on-ethylene total hip replacements. Materials/methods. Implant components from 52 revision cases were evaluated with spot tests for free nickel, cobalt, and chromium (VI) ions. Implant composition was determined with X-ray fluorescence spectroscopy, and information on the reason for revision and complications in relation to surgery was collected from the medical charts when possible (72%). For 10 implants, corrosion was further characterized with scanning electron microscopy.

Results. We detected cobalt release from three of 38 removed femoral heads and from one of 24 femoral stems. Nickel release was detected from one of 24 femoral stems. No chromium(VI) release was detected.

Conclusions. We found that cobalt and nickel were released from some failed total hip arthroplasties, and corrosion was frequently observed. Metal ions and particles corroded from metal-on-polyethylene may play a role in the complex aetio-pathology of implant failure.
2nd Generation Alkaline Electrolysis: Final report
This report provides the results of the 2nd Generation Alkaline Electrolysis project which was initiated in 2008. The project has been conducted from 2009-2012 by a consortium comprising Århus University Business and Social Science – Centre for Energy Technologies (CET (former HIRC)), Technical University of Denmark – Mechanical Engineering (DTU-ME), Technical University of Denmark – Energy Conversion (DTU-EC), FORCE Technology and GreenHydrogen.dk. The project has been supported by EUDP.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Department of Energy Conversion and Storage, Fundamental Electrochemistry, Aarhus University, FORCE Technology, GreenHydrogen.dk
Number of pages: 72
Publication date: 2013

Publication information
Publisher: Århus University Business and Social Science – Centre for Energy Technologies
Original language: English
Electronic versions: 2nd_Generation_Alkaline_Electrolysis.pdf

Bibliographical note
EUDP 63011-0200
Research output: Book/Report › Report – Annual report year: 2013 › Research

Advanced Surface Technology
This new significant book on advanced modern surface technology in all its variations, is aimed at both teaching at engineering schools and practical application in industry. The work covers all the significant aspects of modern surface technology and also describes how new advanced techniques make it possible to examine surfaces all the way down to their atomic layers and also to perform realistic durability tests. The many surface techniques are described in clear and simple language, and the book is richly illustrated with detailed drawings and photos. It also deals with replacing environmentally harmful processes and surfaces that contain chromates and nickel among others.

One chapter is dedicated to hardening of materials based on a wide variety of diffusion based industrial methods by indiffusion of for example nitrogen, carbon, boron, chromium, etc. Examples are given of carburizing, nitriding, carbonitriding, and many other lesser-known thermochemical processes used for solving technological problems. The book is richly illustrated with pictures and figures showing how the technology creates new innovative solutions for industry and how surfaces are becoming integral to the function of the components. It covers everything from biocompatible surfaces of IR absorbent or reflective surfaces to surfaces with specific properties within low friction, hardness, corrosion, colors, etc. The book includes more than 400 pages detailing virtually all analysis methods for examining at surfaces.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Danish Technological Institute
Contributors: Møller, P., Nielsen , L. P.
Number of pages: 1,240
Publication date: 2013

Publication information
Publisher: Møller & Nielsen
Volume: 1-2
ISBN (Print): 9788792765239
Original language: English
Research output: Book/Report › Book – Annual report year: 2013 › Research
Assessment of modified gold surfaced titanium implants on skeletal fixation

Noncemented implants are the primary choice for younger patients undergoing total hip replacements. However, the major concern in this group of patients regarding revision is the concern from wear particles, periimplant inflammation, and subsequently aseptic implant loosening. Macrophages have been shown to liberate gold ions through the process termed dissolucytosis. Furthermore, gold ions are known to act in an anti-inflammatory manner by inhibiting cellular NF-κB-DNA binding. The present study investigated whether partial coating of titanium implants could augment early osseointegration and increase mechanical fixation. Cylindrical porous coated Ti-6Al4V implants partially coated with metallic gold were inserted in the proximal region of the humerus in ten canines and control implants without gold were inserted in contralateral humerus. Observation time was 4 weeks. Biomechanical push out tests and stereological histomorphometrical analyses showed no statistically significant differences in the two groups. The unchanged parameters are considered an improvement of the coating properties, as a previous complete gold-coated implant showed inferior mechanical fixation and reduced osseointegration compared to control titanium implants in a similar model. Since sufficient early mechanical fixation is achieved with this new coating, it is reasonable to investigate the implant further in long-term studies. © 2012 Wiley Periodicals, Inc.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Midwest Orthopaedic and Minneapolis Medical Research Foundations, Aarhus University Hospital, Aarhus University
Contributors: Zainali, K., Danscher, G., Jakobsen, T., Baas, J., Møller, P., Bechtold, J. E., Soballe, K.
Pages: 195-202
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Journal of Biomedical Materials Research. Part A
Volume: 101 A
Issue number: 1
ISSN (Print): 1549-3296
Ratings:
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.15 SJR 1.107 SNIP 1.111
Web of Science (2013): Impact factor 2.841
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Original language: English
Keywords: Arthroplasty, Biomechanics, Coatings, Fracture fixation, Gold, Implants (surgical), Titanium, Gold coatings
DOIs: 10.1002/jbm.a.34307
Source: dtu
Source ID: n::oai:DTIC-ART:compendex/379334415::26093
Research output: Contribution to journal › Journal article – Annual report year: 2013 › Research › peer-review

Consumer leather exposure: an unrecognized cause of cobalt sensitization

BACKGROUND: A patient who had suffered from persistent generalized dermatitis for 7 years was diagnosed with cobalt sensitization, and his leather couch was suspected as the culprit, owing to the clinical presentation mimicking allergic chromium dermatitis resulting from leather furniture exposure.

MATERIALS AND METHODS: The cobalt spot test, X-ray fluorescence, inductively coupled plasma mass spectrometry and scanning electron microscopy were used to determine cobalt content and release from the leather couch that caused the dermatitis and from 14 randomly collected samples of furniture leather.

RESULTS: The sample from the patient's leather couch, but none of the 14 random leather samples, released cobalt in high concentrations. Dermatitis cleared when the patient stopped using his couch.

CONCLUSIONS: Cobalt is used in the so-called pre-metallized dyeing of leather products. Repeated studies have found high levels of cobalt sensitization, but not nickel sensitization, in patients with foot dermatitis. We raise the possibility that cobalt may be widely released from leather items, and advise dermatologists to consider this in patients with positive cobalt patch test reactions. © 2013 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, National Food Institute, Division of Food Chemistry, Copenhagen University Hospital
Contributors: Thyssen, J., Johansen, J. D., Jellesen, M. S., Møller, P., Sloth, J. J., Zachariae, C., Menne, T.
Development of durable and efficient electrodes for large-scale alkaline water electrolysis

A new type of electrodes for alkaline water electrolysis is produced by physical vapour depositing (PVD) of aluminium onto a nickel substrate. The PVD Al/Ni is heat-treated to facilitate alloy formation followed by a selective aluminium alkaline leaching. The obtained porous Ni surface is uniform and characterized by a unique interlayer adhesion, which is critical for industrial application. IR-compensated polarisation curves prepared in a half-cell setup with 1 M KOH electrolyte at room temperature reveals that at least 400 mV less potential is needed to decompose water into hydrogen and oxygen with the developed porous PVD Al/Ni electrodes as compared to solid nickel electrodes. High-resolution scanning electron microscope (HR-SEM) micrographs reveal Ni-electrode surfaces characterized by a large surface area with pores down to a few nanometre sizes. Durability tests were carried out in a commercially produced bipolar electrolyser stack. The developed electrodes showed stable behaviour under intermittent operation for over 9000 h indicating no serious deactivation in the density of active sites.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Danish Technological Institute
Contributors: Kjartansdóttir, C. K., Nielsen, L. P., Møller, P.
Pages: 8221-8231
Publication date: 2013
Peer-reviewed: Yes

Electroplated tin-nickel coatings as a replacement for nickel to eliminate nickel dermatitis

Nickel dermatitis (skin allergy) is a growing problem in numerous countries. The alarming frequency of sensitization to nickel especially in the US caused nickel to be selected as the "Allergen of the Year" in 2008 by the American Contact Dermatitis Society. Nickel as coating in contact with skin has already been regulated by the nickel EU directive [94/27/EC]...
since 1994. In the present contribution tin/nickel alloy coatings (66.9 wt. % Sn), electrodeposited from a chloride/fluoride containing alloy electrolyte, will be presented as an alternative for both nickel and bright chromium coatings. The main focus will be on the corrosion properties where the following corrosion investigations will be covered; corrosion potential measurements for the different coatings, estimation of corrosion rates for materials in galvanic coupling with tin/nickel coatings, salt spray test, medical tests and immersion test of tin/nickel coatings in artificial sweat. Copyright © (2013) by the National Association for Surface Finishing.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Møller, P., Boyce, J. M., Nielsen, L. P.
Pages: 874-885
Publication date: 2013

Host publication information
Title of host publication: National Association for Surface Finishing Annual Conference and Trade Show (SUR/FIN 2013)
Publisher: National Association for Surface Finishing
Keywords: Chlorine compounds, Coatings, Commerce, Corrosion, Dermatitis, Exhibitions, Finishing, Nickel, Societies and institutions, Tin, Nickel coatings, Alloy electrolytes, Chromium coatings, Contact dermatitis, Corrosion potential measurement, Corrosion property, Galvanic coupling, Immersion tests, Salt Spray test, SUR/FIN
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2013 › Research › peer-review

Evaluation of atmospheric corrosion on electroplated zinc and zinc nickel coatings by Electrical Resistance (ER) Monitoring
ER (Electrical Resistance) probes provide a measurement of metal loss, measured at any time when a metal is exposed to the real environment. The precise electrical resistance monitoring system can evaluate the corrosion to the level of nanometers, if the conductivity is compensated for temperature and magnetic fields. With this technique very important information about the durability of a new conversion coatings for aluminum, zinc and zinc alloys exposed to unknown atmospheric conditions can be gathered. This is expected to have a major impact on a number of industrial segments, such as test cars for the automotive industry, off-shore construction or component and devices used in harsh industrial environments. The ER monitoring makes it possible to study the corrosion rate on-line in remote locations as a function of temperature, relative humidity and changes in the composition of the atmosphere. Different coatings of zinc, zinc/nickel without and with different Cr+3 conversion coatings were tested in salt spray, and the corrosions rate was recorded every 5 minutes. The results will be discussed and compared. Copyright © (2013) by the National Association for Surface Finishing.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Møller, P.
Pages: 583-591
Publication date: 2013

Host publication information
Title of host publication: National Association for Surface Finishing Annual Conference and Trade Show (SUR/FIN 2013)
Publisher: National Association for Surface Finishing
Keywords: Aluminum coatings, Atmospheric corrosion, Automotive industry, Chromate coatings, Commerce, Electric resistance, Exhibitions, Finishing, Societies and institutions, Zinc, Zinc coatings
Source: dtu
Source ID: n:oai:DTIC-ART:compendex/426544115::34853
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2013 › Research › peer-review

Steam Assisted Accelerated Growth of Oxide Layer on Aluminium Alloys
Corrosion resistance of aluminium alloys is related to the composition and morphology of the oxide film on the surface of aluminium. In this paper we investigated the use of steam on the surface modification of aluminium to produce boehmite films. The study reveals a detailed investigation of the effect of vapour pressure, structure of intermetallic particles and thickness of boehmite films on the corrosion behaviour of aluminium alloys.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering
Characterization of a Cobalt-Tungsten Interconnect

A ferritic steel interconnect for a solid oxide fuel cell must be coated in order to prevent chromium evaporation from the steel substrate. The Technical University of Denmark and Topsoe Fuel Cell have developed an interconnect coating based on a cobalt-tungsten alloy. The purpose of the coating is to act both as a diffusion barrier for chromium and provide better protection against high temperature oxidation than a pure cobalt coating.

This work presents a characterization of a cobalt-tungsten alloy coating electrodeposited on the ferritic steel Crofer 22 H which subsequently was oxidized in air for 300 h at 800 °C. The coating was characterized with Glow Discharge Optical Spectroscopy (GDOES), Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD). The oxidation properties were evaluated by measuring weight change of coated samples of Crofer 22 H and Crofer 22 APU as a function of oxidation time.

The coating had completely oxidized during the 300 h oxidation time. GDOES measurements showed that the tungsten was located in an inner zone in the coating/substrate interface. The outer layer of the coating did not contain any tungsten after oxidation but consisted mainly of cobalt and oxygen with smaller amounts of iron and manganese. The iron and manganese had diffused from the steel into the coating during oxidation. XRD measurements showed that tungsten reacts with cobalt and oxygen to form CoWO4. Cobalt oxide in the outer layer was a spinel of either Co3O4 or Co3-y(Mn,Fe)yO4. Chromium in the steel had oxidized to form a thin layer of almost pure chromium oxide underneath the coating.

The coating appears to be an effective diffusion barrier for chromium as a very small amount of chromium was measured.
in the coating after oxidation. The cobalt-tungsten coated samples oxidized slightly slower than the cobalt coated samples.

An interconnect used in a fuel cell stack was also investigated with SEM/EDS. The interconnect from the fuel cell stack was different from the samples oxidized in the furnace with respect to the location of the tungsten. The tungsten in the interconnect coating was present in the chromium oxide layer instead of as CoW\textsubscript{o}4 on top of it.

**General information**

Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Haldor Topsoe AS, Technical University of Denmark
Contributors: Harthøj, A., Holt, T., Caspersen, M., Møller, P.
Pages: 21/118 - 34/118
Publication date: 2012

**Host publication information**

Title of host publication: Proceedings of 10th European SOFC Forum
Editor: Lefebvre-Joud (et al.), F.
Source: dtu
Source ID: u::4463
Research output: Chapter in Book/Report/Conference proceeding - Article in proceedings – Annual report year: 2012 - Research - peer-review

**Effect of No-Clean Flux Residues on the Performance of Acrylic Conformal Coating in Aggressive Environments**

The influence of no-clean flux residues on the performance of acrylic conformal coating used for printed circuit board (PCB) assemblies was investigated under aggressive exposure conditions using plain coated laminates and PCBs with comb shaped surface insulation resistance (SIR) pattern. Plain laminate substrate and SIR PCBs were cleaned or dosed with no-clean flux residues prior to coatings. Performance studies were carried out by total immersion in deionized water at 60°\textdegree{C} for 10 days followed by microscopic investigations and potentiostatic studies on coated SIR patterns at 12 V potential bias and by measuring the resulting leakage current. Foe both plain laminates and SIR patterns, detailed investigation of the corrosion morphology was carried out. The amount of water intake by the coating was calculated by the weight-gain method. The amount of no-clean flux residue resulting at various temperatures was quantified using ion chromatography by extracting the residue, and surface morphology of the residues was investigated using optical microscopy. The flux residue in general consists of both resin and activator components such as carboxylic acids. Coated samples with flux residues after exposure showed blisters all over the surface and reduction in adhesion strength. The coated SIR PCBs with flux residues also showed failure due to electrochemical migration more quickly than on the clean PCBs.

**General information**

Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Rathinavelu, U., Jellesen, M. S., Møller, P., Ambat, R.
Pages: 719-728
Publication date: 2012
Peer-reviewed: Yes

**Publication information**

Journal: IEEE Transactions on Components, Packaging and Manufacturing Technology
Volume: 2
Issue number: 4
ISSN (Print): 2156-3950
Ratings:
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.67 SJR 0.426 SNIP 1.355
Web of Science (2012): Impact factor 1.261
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Original language: English
Keywords: Acrylic, Blisters, Conformal coating, electrochemical migration, No-clean flux
DOIs: 10.1109/TCPMT.2012.2186456

**Bibliographical note**

This work was supported in part by the Danish Ministry of Science, Technology and Innovation under the CELCORR project, the CELCORR consortium, the Project partners Danfoss A/S, Grundfos A/S, Vestas A/S, and Pridana A/S, the Danish Technological Institute, and the IPU. Recommended for publication by Associate Editor M. Ramkumar upon
Effect of pressurized steam on AA1050 aluminium

Purpose - The purpose of this paper is to understand the effect of pressurized steam on surface changes, structures of intermetallic particles and corrosion behavior of AA1050 aluminium. Design/methodology/approach - Industrially pure aluminium (AA1050, 99.5 per cent) surfaces were exposed to pressurized steam produced from a commercial pressure cooker at the maximum temperature of 116°C for 10 min. Surface morphology was observed using SEM-EDX and FIB-SEM. Phase identification and compositional depth profiling were investigated using XRD and GDOES, respectively. Potentiodynamic polarization measurements were used to study corrosion behavior.

Findings - A 590 nm boehmite oxide layer was generated on AA1050 associated with partially dissolved and/or fallen off Fe-containing intermetallic particles after exposure to pressurized steam. A significant reduction (25 times) in anodic and cathodic reactivities was observed due to the formation of the compact oxide layer.

Originality/value - This paper reveals a detailed investigation of how pressurized steam can affect the corrosion behaviour of AA1050 aluminium and the structure of Fe-containing intermetallic particles.

Factors affecting the wettability of different surface materials with vegetable oil at high temperatures and its relation to cleanability

The main aim of the work was to investigate the wettability of different surface materials with vegetable oil (olive oil) over the temperature range of 25–200°C to understand the differences in cleanability of different surfaces exposed to high temperatures in food processes. The different surface materials investigated include stainless steel (reference), PTFE (polytetrafluoroethylene), silicone, quasicrystalline (Al, Fe, Cr) and ceramic coatings: zirconium oxide (ZrO2), zirconium nitride (ZrN) and titanium aluminum nitride (TiAlN). The ceramic coatings were deposited on stainless steel with two different levels of roughness. The cosine of the contact angle of olive oil on different surface materials rises linearly with increasing temperature. Among the materials analyzed, polymers (PTFE, silicone) gave the lowest cosθ values. Studies of the effect of roughness and surface flaws on wettability revealed that the cosθ values increases with increasing roughness and surface flaws. Correlation analysis indicates that the measured contact angle values gave useful information for grouping easy-clean polymer materials from the other materials; for the latter group, there is no direct relation between contact angle and cleanability. In addition to surface wettability with oil many other factors such as roughness and surface defects play an essential role in determining their cleanability.
Nickel allergy and dermatitis following use of a laptop computer

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Esbjerg Clinic of Dermatology, Copenhagen University Hospital
Contributors: Jensen, P., Jellesen, M. S., Møller, P., Frankild, S., Johansen, J. D., Menné, T., Thyssen, J. P.
Pages: e170–e171
Publication date: 2012
Peer-reviewed: No

Publication information
Volume: 67
Issue number: 4
ISSN (Print): 0190-9622
Ratings:
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.63 SJR 1.902 SNIP 2.219
Web of Science (2012): Impact factor 4.906
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Original language: English
DOIs:
10.1016/j.jaad.2012.01.033
Source: dtu
Source ID: n:oai:DTIC-ART:elsevier/369610145::19354
Research output: Contribution to journal › Letter – Annual report year: 2012 › Research

Nickel may be released from laptop computers
Consumer nickel sensitization and dermatitis is caused by prolonged or repeated skin exposure to items that release nickel, for example jewellery, belts, buttons, watches, and mobile phones (1–3). We recently described a patient in whom primary nickel contact sensitization and dermatitis developed following the use of an Apple laptop computer (4). To estimate nickel release from Apple laptop computers, we investigated a random sample of 20 devices.
Biologically Inhibiting Material a method of Producing Said Material as Well as the Use at Said Material for Inhibiting Live Cells

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Technical University of Denmark
Contributors: Hilbert, L. R., Møller, P., Jensen, E.
Publication date: 2011

Publication information
Country: Canada
Patent number: CA 2506591
Filing date: 02/08/2011
Original language: English
Source: orbit
Source ID: 317019
Research output: Patent – Annual report year: 2011 – Research

Effect of chloride impurities on the performance and durability of polybenzimidazole-based high temperature proton exchange membrane fuel cells

The effect of chloride as an air impurity and as a catalyst contaminant on the performance and durability of polybenzimidazole (PBI)-based high temperature proton exchange membrane fuel cell (HT-PEMFC) was studied. The ion chromatographic analysis reveals the existence of chloride contaminations in the Pt/C catalysts. Linear sweep voltammetry was employed to study the redox behavior of platinum in 85% phosphoric acid containing chloride ions, showing increase in oxidation and decrease in reduction current densities during the potential scans at room temperature. The potential scans at high temperatures in 85% phosphoric acid containing chloride ions showed both increase in oxidation and reduction current densities. The fuel cell performance, i.e. the current density at a constant voltage of 0.4 V and 0.5 V was found to be degraded as soon as HCl was introduced in the air humidifier. The performance loss was recovered when switching from the HCl solution back to pure water in the air humidifier. Under an accelerated aging performance test conducted through potential cycling between 0.9 V and 1.2 V, the PBI-based fuel cell initially containing 0.5 NaCl mg cm−2 on the cathode catalyst layer exhibited a drastic degradation in the performance as compared to the chloride free MEAs. The mechanisms of the chloride effect on the fuel cell performance and durability were further discussed.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Energy and Materials, Department of Chemistry, Danish Technological Institute
Electrochemical migration of tin in electronics and microstructure of the dendrites

The macro-, micro-, and nano-scale morphology and structure of tin dendrites, formed by electrochemical migration on a surface mount ceramic chip resistor having electrodes consisting of tin with small amounts of Pb (~2wt.%) was investigated by scanning electron microscopy and transmission electron microscopy including Energy dispersive X-ray spectroscopy and electron diffraction. The tin dendrites were formed under 5 or 12V potential bias in 10ppm by weight NaCl electrolyte as a micro-droplet on the resistor during electrochemical migration experiments. The dendrites formed were found to have heterogeneous microstructure along the growth direction, which is attributed to unstable growth conditions inside the micro-volume of electrolyte. Selected area electron diffraction showed that the dendrites are metallic tin having sections of single crystal orientation and lead containing intermetallic particles embedded in the structure. At certain areas, the dendrite structure was found to be surrounded by an oxide crust, which is believed to be due to unstable growth conditions during the dendrite formation. The oxide layer was found to be of nanocrystalline structure, which is expected to be formed by the dehydration of the hydrated oxide originally formed in solution ex-situ in ambient air.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering
Contributors: Minzari, D., Grumsen, F. B., Jellesen, M. S., Møller, P., Ambat, R.
Pages: 1659-1669
Publication date: 2011
Peer-reviewed: Yes
FIB-SEM investigation of trapped intermetallic particles in anodic oxide films on AA1050 aluminium

Purpose - The purpose of this investigation is to understand the structure of trapped intermetallics particles and localized composition changes in the anodized anodic oxide film on AA1050 aluminium substrates. Design/methodology/approach - The morphology and composition of Fe-containing intermetallic particles incorporated into the anodic oxide films on industrially pure aluminium (AA1050, 99.5 per cent) has been investigated. AA1050 aluminium was anodized in a 100 ml/l sulphuric acid bath with an applied voltage of 14 V at 20°C ±2°C for 10 or 120 min. The anodic film subsequently was analyzed using focused ion beam-scanning electron microscopy (FIB-SEM), SEM, and EDX. Findings - The intermetallic particles in the substrate material consisted of Fe or both Fe and Si with two different structures: irregular and round shaped. FIB-SEM cross-sectioned images revealed that the irregular-shaped particles were embedded in the anodic oxide film as a thin strip structure and located near the top surface of the film, whereas the round-shaped particles were trapped in the film with a spherical structure, but partially dissolved and were located throughout the thickness of the anodic film. The Fe/Si ratio of the intermetallic particles decreased after anodizing. Originality/value - This paper shows that dual beam FIB-SEM seems to be an easy, less time consuming and useful method to characterize the cross-sectioned intermetallic particles incorporated in anodic film on aluminium.

Morphological study of silver corrosion in highly aggressive sulfur environments

A silicone coated power module, having silver conducting lines, showed severe corrosion, after prolonged use as part of an electronic device in a pig farm environment, where sulfur containing corrosive gasses are known to exist in high amounts. Permeation of sulfur gasses and humidity through the silicone coating to the interface has resulted in three corrosion types namely: uniform corrosion, conductive anodic filament type of Ag2S growth, and silver migration with subsequent formation of sulfur compounds. Detailed morphological investigation of new and corroded power modules was carried out, and possible theoretical explanation for various corrosion mechanisms has been attempted.
On the electrochemical migration mechanism of tin in electronics

Electrochemical migration (ECM) of tin can result in the growth of a metal deposit with a dendritic structure from cathode to anode. In electronics, such growth can lead to short circuit of biased electrodes, potentially leading to intermittent or complete failure of an electronic device. In this paper, mechanistic aspects of ECM of tin are discussed in detail, using experimental results on ECM of tin in various environments and varying potential bias. Results on the formation of local pH changes by the electrodes and experiments observations are combined with thermodynamic stability of tin species as depicted in the Pourbaix diagram.

Process, kit and composition for detecting residues and contaminants in an object with three-dimensional geometry

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Minzari, D., Jellesen, M. S., Ambat, R., Møller, P., Westermann, P. J. S.
Publication date: 2011
Peer-reviewed: Yes
A spot test for detection of cobalt release – early experience and findings

Background: It is often difficult to establish clinical relevance of metal exposure in cobalt-allergic patients. Dermatologists and patients may incorrectly assume that many metallic items release cobalt at levels that may cause cobalt dermatitis. Cobalt-allergic patients may be unaware that they are exposed to cobalt from handling work items, causing hand dermatitis. Objectives: To present early findings with a newly developed cobalt spot test. Methods and Results: A cobalt spot test based on disodium-1-nitroso-2-naphthol-3,6-disulfonate was able to identify cobalt release at 8.3 ppm. The test may also be used as a gel test if combined with an agar preparation. We found no false-positive reactions when testing metals and alloys known not to contain cobalt. However, one cobalt-containing alloy, which elicited cobalt dermatitis in cobalt-allergic patients, was negative upon cobalt gel testing. Conclusions: The cobalt test detects amounts of cobalt release that approximate the elicitation concentration seen in cobalt-allergic patients. It may serve as a useful tool in dermatology offices and workplaces.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Karolinska Institutet, Copenhagen University Hospital
Contributors: Thyssen, J. P., Menné, T., Johansen, J. D., Lidén, C., Julander, A., Møller, P., Jellesen, M. S.
Pages: 63-69
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Contact Dermatitis
Volume: 63
Issue number: 2
ISSN (Print): 0105-1873
Ratings:
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.826 SNIP 1.172
Web of Science (2010): Impact factor 3.672
Web of Science (2010): Indexed yes
Original language: English
Keywords: screening, spot test, cobalt, dermatitis, allergy
DOIs:
Cleanability Evaluation of Different Surfaces by Fouling from Contact Frying of Foods

General information
Publication status: Published
Organisations: Division of Food Production Engineering, National Food Institute, Materials and Surface Engineering, Department of Mechanical Engineering, Technical University of Denmark
Contributors: Ashokkumar, S., Raagaard Thomsen, B., Hinke, J., Møller, P., Adler-Nissen, J.
Number of pages: 302
Pages: 24-33
Publication date: 2010

Host publication information
Title of host publication: Fouling and Cleaning in Food Processing 2010
Place of publication: UK
Publisher: Cambridge University Press
ISBN (Print): 978-09542483-2-1
URLs:

Cobalt release from inexpensive jewellery: has the use of cobalt replaced nickel following regulatory intervention?

Objectives: The aim was to study 354 consumer items using the cobalt spot test. Cobalt release was assessed to obtain a risk estimate of cobalt allergy and dermatitis in consumers who would wear the jewellery. Methods: The cobalt spot test was used to assess cobalt release from all items. Microstructural characterization was made using scanning electron microscope (SEM) and energy-dispersive spectroscopy (EDS). Results: Cobalt release was found in 4 (1.1%) of 354 items. All these had a dark appearance. SEM/EDS was performed on the four dark appearing items which showed tin-cobalt plating on these. Conclusions: This study showed that only a minority of inexpensive jewellery purchased in Denmark released cobalt when analysed with the cobalt spot test. As fashion trends fluctuate and we found cobalt release from dark appearing jewellery, cobalt release from consumer items should be monitored in the future. Industries may not be fully aware of the potential cobalt allergy problem.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Karolinska Institutet, Copenhagen University Hospital
Contributors: Thyssen, J. P., Jellesen, M. S., Menné, T., Lidén, C., Julander, A., Møller, P., Johansen, J. D.
Pages: 70-76
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Contact Dermatitis
Volume: 63
ISSN (Print): 0105-1873
Ratings:
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.826 SNIP 1.172
Web of Science (2010): Impact factor 3.672
Web of Science (2010): Indexed yes
Original language: English
Keywords: screening, spot test, jewellery, cobalt allergy, cobalt dermatitis, cobalt ions
DOIs:
10.1111/j.1600-0536.2010.01749.x
Source: orbit
Source ID: 259558
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2010 › Research › peer-review
Corrosion failure due to flux residues in an electronic add-on device
Corrosion of components and sub-assemblies on an electronic Printed Circuit Board Assembly (PCBA) is a major reliability concern. Both process and user related contamination will influence the corrosion reliability of a PCBA and the electronic device as a whole. An important process related contamination is solder flux residues which can act as a corrosion promoter in humid atmosphere due to the presence of ionic substances and a resin component. The presence of ionic substances will increase the conductivity of a condensed water layer and influence corrosion processes, depending on the species present. The resin component can easily attract dust during operation, which will eventually make surfaces hydrophilic and are thus become a potential source for ions. This paper describes the failure analysis of tactile switches, used in PCBAs mounted in wind turbines. More detailed investigation of the electrochemical behavior of metallic materials (alloys) used in the switch and risk of electrochemical migration (ECM) between the switch components in presence of flux residues was also carried out. Investigations included potentiodynamic polarization measurements on the switch electrodes using a micro-electrochemical technique, in situ ECM studies, and scanning electron microscopy (SEM). Failure of the switches was found to be either due to the flux residue acting as an insulating layer or as a corrosion accelerator causing ECM.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering
Contributors: Jellesen, M. S., Minzari, D., Rathinavelu, U., Møller, P., Ambat, R.
Pages: 1263-1272
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Engineering Failure Analysis
Volume: 17
Issue number: 6
ISSN (Print): 1350-6307
Ratings:
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.811 SNIP 1.579
Web of Science (2010): Impact factor 0.77
Web of Science (2010): Indexed yes
Original language: English
Keywords: Electronic-device failures, Corrosion, Reliability analysis
DOI:
10.1016/j.engfailanal.2010.02.010
Source: orbit
Source ID: 268175

Influence of annealing and deformation on optical properties of ultra precision diamond turned and anodized 6060 aluminium alloy
Influence of cold forging, and subsequent heat treatment and diamond turning on optical quality of anodized film on 6060 (AlMgSi) alloy was investigated and compared with microstructural changes. Heat treatment of the samples was carried out either prior to forging, post-forging, or both. The surface of the forged material was then diamond turned to a mirror like finish. The diamond turned samples were subsequently anodized in a sulphuric acid bath. The microstructure of the samples was analysed using optical microscopy (LOM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). Colour/brightness measurements were carried out using CIE Lab system. An optical method was used to measure the thickness of the oxide film and roughness of the surface was measured before and after anodizing using stylus, a mechanical instrument, and bidirectional reflection distribution function (BRDF), an optical instrument. Results indicated that the post-forging heat treatment had a great influence on the appearance of the anodized layer, which was also a function of the deformation introduced prior to heat treatment. The effect was assumed to be attributed to the change in microstructure, especially the distribution and the amount of the intermetallic particles such as elemental Si and Mg2Si. Roughness of the oxide film was also found to be a function of the heat treatment and deformation condition.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Materials and Surface Engineering, Dansk Fundamental Metrology A/S
Contributors: Tabrizian-Ghalehno, N., Hansen, H. N., Hansen, P., Ambat, R., Møller, P.
Influence of quartz particles on wear in vertical roller mills. Part I: Quartz concentration
The standard closed circuit comminution process commonly employed in industrial vertical roller mills has been analyzed to determine the influence of typical abrasive minerals on wear rates. With the main focus on raw mixes used in cement plants, synthetic mixtures imitating were prepared. Using statistical planning, a total of 10 tests were carried out with two different limestones and one type of quartz sand. The size distributions were kept constant and only the mixing ratios were varied. It appears from the investigation that mixtures consisting of minerals with different grindabilities result in an increased concentration of abrasive particles in the grinding bed \( R^2 > 0.99 \). The present study shows that the quartz concentration in the grinding bed is determining the wear rate.

Influence of silver additions to type 316 stainless steels on bacterial inhibition, mechanical properties, and corrosion resistance
Bacterial contamination is a major concern in many areas. In this study, silver was added to type 316 stainless steels in order to obtain an expected bacteria inhibiting property to reduce the occurrence of bacterial contamination. Silver-bearing 316 stainless steels were prepared by vacuum melting techniques. The microstructure of these 316 stainless steels was
examined, and the influences of silver additions to 316 stainless steels on bacterial inhibition, mechanical properties, and corrosion resistance were investigated. This study suggested that silver-bearing 316 stainless steels could be used in areas where hygiene is a major requirement. The possible mechanisms of silver dissolution from the surfaces of silver-bearing 316 stainless steels were also discussed in this report.

**General information**
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, National Taiwan Ocean University, FORCE Technology, University of Copenhagen
Contributors: Chiang, W., Tseng, I., Møller, P., Hilbert, L. R., Tolker-Nielsen, T., Wu, J.
Pages: 123-130
Publication date: 2010
Peer-reviewed: Yes

**Publication information**
Journal: Materials Chemistry and Physics
Volume: 119
Issue number: 1-2
ISSN (Print): 0254-0584
Ratings:
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.048 SNIP 1.257
Web of Science (2010): Impact factor 2.356
Web of Science (2010): Indexed yes
Original language: English
DOIs:
10.1016/j.matchemphys.2009.08.035
Source: orbit
Source ID: 251858
Research output: Contribution to journal › Journal article – Annual report year: 2010 › Research › peer-review

**Investigation of Electronic Corrosion at Device Level**
This work presents device level testing of a lead free soldered electronic device tested with bias on under cyclic humidity conditions in a climatic chamber. Besides severe temperature and humidity during testing some devices were deliberately contaminated before testing. Contaminants investigated are ionic or airborne contaminants likely to be introduced by production or service conditions. The effect of changes in processing parameters as a result of production shift to lead free solder (e.g. higher soldering temperature) has also been investigated. Analysis have shown that one printed circuit board assembly (PCBA) in the device is more prone to corrosion reliability and this was further analysed using thermography to detect areas that have high risk of condensation due to lower temperature under working condition. Tested PCBAs are subjected to detailed investigation before and after testing using high resolution photography, detailed optical microscopy and SEM/EDS.

**General information**
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering
Contributors: Jellesen, M. S., Minzari, D., Rathinavelu, U., Møller, P., Ambat, R.
Pages: 1-14
Publication date: 2010
Peer-reviewed: Yes

**Publication information**
Journal: E C S Transactions
Volume: 25
Issue number: 30
ISSN (Print): 1938-5862
Ratings:
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.249 SNIP 0.252
Original language: English
Electronic versions:
Minzari.pdf
DOIs:
10.1149/1.3321952
Mechanisms of electrochemical migration of tin by in-situ optical and electron microscopy

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Department of Micro- and Nanotechnology
Contributors: Minzari, D., Jellesen, M. S., Møller, P., Grumsen, F. B., Mølhave, K., Jensen, E., Ambat, R.
Publication date: 2010

Host publication information
Title of host publication: Eurocorr 2010
Source: orbit
Source ID: 273981

On the application of thermodynamics of corrosion for service life design of concrete structures
There are unexploited possibilities in the application of thermodynamics of corrosion for service life design (SLD) of concrete structures. Thermodynamics provides means for insightful descriptions of corrosion mechanisms and of corrosion protection mechanisms. Strategies for corrosion protection can be based on thermodynamically consistent corrosion mechanisms and evaluation of existing and design of new countermeasures can be performed using thermodynamics. Similarly, materials concepts for embedded electrodes can be designed using thermodynamics. The present paper provides a brief outline of the application of thermodynamics for SLD and gives examples of two applications: description of corrosion processes and design of countermeasures. Emphasis is set on chloride induced corrosion.

General information
Publication status: Published
Organisations: Section for Construction Materials, Department of Civil Engineering, Materials and Surface Engineering, Department of Mechanical Engineering, COWI A/S
Contributors: Küter, A., Geiker, M. R., Møller, P.
Number of pages: 1,214
Pages: 637-644
Publication date: 2010

Host publication information
Title of host publication: Service Life Design for Infrastructure : Proceedings of the 2nd International Symposium Volume: 2
Place of publication: France
Publisher: RILEM Publications s.a.r.l.
ISBN (Print): 978-2-35158-096-7
Source: orbit
Source ID: 272264

Prediction of wear rates in comminution equipment
Raw material comminution equipment may be exposed to excessive wear, which makes it difficult to operate minerals processing plants continuously because lengthy and unplanned shut-downs interrupt the overall process. In general, most comminution equipment is fine-tuned to operate at low vibrations and to achieve guaranteed performance. From an economical point of view, it is always preferred to replace all worn parts during the planned maintenance shutdowns. When operating comminution equipment, the wear rate receives little attention and is considered a secondary matter. However, experience shows that a wear map can give eye-opening information on the wear behavior. A wear map provides insight into the interaction between the abrasive and the wear part material being studied. In this paper, three
wear maps with highly different properties are compared. Testing was performed on an abrasion-resistant high chromium white cast iron (21988/JN/HBW555XCr21), a heat-treated wear resistant steel (Hardox 400) and a plain carbon construction steel (S235). Quartz, which accounts for the largest wear loss in the cement industry, was chosen as abrasive. Other process parameters such as velocity (1–7 m/s) and pressure (70–1400 kPa) were chosen to closely imitate real industrial processes. The authors are aware that a number of wear mechanisms such as erosion, fatigue and abrasion may occur simultaneously in comminution equipment. Nonetheless, this paper aims at discussing abrasion only due to its large contribution in the material removal process. The vertical roller mill has received special attention and this paper also discusses a simplified view on wear.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Fundal Consult, FLSmidth & Co. A/S
Contributors: Jensen, L. R. D., Fundal, E., Møller, P., Jespersen, M.
Pages: 525-533
Publication date: 2010
Peer-reviewed: Yes

Quantification of in situ temperature measurements on a PBI-based high temperature PEMFC unit cell
The temperature is a very important operating parameter for all types of fuel cells. In the present work distributed in situ temperature measurements are presented on a polybenzimidazole based high temperature PEM fuel cell (HT-PEM). A total of 16 T-type thermocouples were embedded on both the anode and cathode flow plates. The purpose of this study is to investigate the feasibility of the proposed temperature characterization method and to identify the temperature distribution on an operating HT-PEM in various modes of operation, including a 700 h sensors durability test. The embedded sensors showed minimal influence on cell performance, this difference seen in performance is believed to be caused by different bipolar plate materials. The measurement method is suitable for obtaining detailed data for validation of computational models, moreover the results indicate that the method can be used as a degradation tool, as it is possible to locate areas exposed to degradation, both in plane and between the anode and cathode.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Danish Technological Institute, Aalborg University
Pages: 9943-9953
Publication date: 2010
Peer-reviewed: Yes

Quantification of in situ temperature measurements on a PBI-based high temperature PEMFC unit cell
The temperature is a very important operating parameter for all types of fuel cells. In the present work distributed in situ temperature measurements are presented on a polybenzimidazole based high temperature PEM fuel cell (HT-PEM). A total of 16 T-type thermocouples were embedded on both the anode and cathode flow plates. The purpose of this study is to investigate the feasibility of the proposed temperature characterization method and to identify the temperature distribution on an operating HT-PEM in various modes of operation, including a 700 h sensors durability test. The embedded sensors showed minimal influence on cell performance, this difference seen in performance is believed to be caused by different bipolar plate materials. The measurement method is suitable for obtaining detailed data for validation of computational models, moreover the results indicate that the method can be used as a degradation tool, as it is possible to locate areas exposed to degradation, both in plane and between the anode and cathode.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Danish Technological Institute, Aalborg University
Pages: 9943-9953
Publication date: 2010
Peer-reviewed: Yes

Publication information
Volume: 35
Issue number: 18
ISSN (Print): 0360-3199
Ratings:
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.579 SNIP 1.859
The effect of atmospheric corona treatment on AA1050 aluminium
The effect of atmospheric corona discharge on Al 050 aluminium surface was investigated using electrochemical polarization, SEM-EDX, FIB-SEM, and XPS. The corona treatment was performed with varying time (1, 5, and 15 min) in atmospheric air. A 200 nm oxide layer was generated on AA1050 after the 15 min air corona treatment. A significant reduction in anodic and cathodic reactivities was observed starting from 1 min exposure, which further decreased with prolonged exposure (15 min) and after delayed testing (after 30 days). The reduction in surface reactivity is due to the formation of thicker and denser oxide film.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Center for Electron Nanoscopy, Experimental Surface and Nanomaterials Physics, Department of Physics
Contributors: Jariyaboon, M., Møller, P., Dunin-Borkowski, R. E., In, S., Chorkendorff, I., Ambat, R.
Pages: 2155-2163
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Corrosion Science
Volume: 52
Issue number: 6
ISSN (Print): 0010-938X
Ratings:
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.396 SNIP 2.51
Web of Science (2010): Impact factor 3.265
Web of Science (2010): Indexed yes
Original language: English
Keywords: Oxide coatings, Aluminium, Polarization
DOI:
10.1016/j.corsci.2010.01.035
Source: orbit
Source ID: 263416
Research output: Contribution to journal > Journal article – Annual report year: 2010 > Research > peer-review

Thin film thermocouples for in situ membrane electrode assembly temperature measurements in a polybenzimidazole-based high temperature proton exchange membrane unit cell
This paper presents Type-T thin film thermocouples (TFTCs) fabricated on Kapton (polyimide) substrate for measuring the internal temperature of PBI(polybenzimidazole)-based high temperature proton exchange membrane fuel cell (HT-PEMFC). Magnetron sputtering technique was employed to deposit a 2 µm thick layer of TFTCs on 75 µm thick Kapton foil. The Kapton foil was treated with in situ argon plasma etching to improve the adhesion between TFTCs and the Kapton substrate. The TFTCs were covered with a 7 µm liquid Kapton layer using spin coating technique to protect them from environmental degradation. This Kapton foil with deposited TFTCs was used as sealing inside a PBI (polybenzimidazole)-based single cell test rig, which enabled measurements of in situ temperature variations of the working fuel cell MEA. The performance of the TFTCs was promising with minimal interference to the operation of the fuel cell.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Aalborg University, Danish Technological Institute
Pages: 4835-4841
Contact Angle Analysis of Sol-gel derived Zirconia based Hybrid Coatings on 304 Stainless Steel Substrates

General information
Publication status: Published
Organisations: Division of Food Production Engineering, National Food Institute, Materials and Surface Engineering, Department of Mechanical Engineering
Contributors: Ashokkumar, S., Adler-Nissen, J., Møller, P.
Publication date: 2009

Event information
Event: International Conference on Metallurgical Coatings and Thin Films
Location: San Diego, California, United States
Source: orbit
Source ID: 243531
Research output: Non-textual form › Sound/Visual production (digital) – Annual report year: 2009 › Research

CORROSION AND WEAR PROPERTIES OF MATERIALS USED FOR MINCED MEAT PRODUCTION
The risk of material degradation is present in minced-meat processing equipment. Corrosion, wear and tribocorrosion properties of commonly used steel materials for such processing equipment are therefore studied in detail. Corrosiveness of minced meat has been evaluated by potentiodynamic measurements. Combined sliding wear and corrosion conditions have been simulated in laboratory using a block-on-ring setup allowing for electrochemical measurements. Detailed information concerning the mechanism of possible material degradation is provided by these results, together with microstructural analysis and thermodynamic considerations. Areas of precaution are stated and new material solutions are suggested.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Fluid Mechanics, Department of Management Engineering
Contributors: Jellesen, M. S., Hansen, M. O. L., Hilbert, L. R., Møller, P.
Pages: 463-477
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Journal of Food Process Engineering
Volume: 32
Issue number: 4
ISSN (Print): 0145-8876
Ratings:
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.487 SNIP 0.593
Effect of Solder Flux Residues on Corrosion of Electronics

Flux from 'No Clean' solder processes can cause reliability problems in the field due to aggressive residues, which may be electrical conducting or corrosive in humid environments. The solder temperature during a wave solder process is of great importance to the amount of residues left on a PCBA. 'No Clean' fluxes typically contain about 2 wt% solids, 96 wt% alcohol, 1 wt% water and 1 wt% additives. It is assumed that all aggressive additives and solids (acids and ester oil compounds) evaporate during the solder process, which is the reason for the name 'No Clean', which means that no cleaning after the solder process is required. In some cases, however, this statement is not correct. Experiments with 'No Clean' wave solder flux have been performed, and the results show that the solder temperature plays an important role; temperatures below 170°C cause more flux residues than solder temperatures above about 235°C. The reason is that the acid part of the flux does not evaporate completely at the lower temperatures, and as acid can be dissolved in water, leakage currents and product failures can occur in humid environments. Also remaining ester oil can act as a site for entrapment of dust, which can act as a humidity absorber. The experiments have been made on SnPb wave solder flux, later experiments will show if the problems are less for Lead-free reflow and wave soldering, because the solder temperature is about 20°C higher. Furthermore an example of failure after humidity testing and use in the field, consequences and recommendations are given. Failures, caused by harsh customer environments, are not covered in this paper.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, Danfoss AS
Contributors: Hansen, K. S., Jellesen, M. S., Møller, P., Westermann, P. J. S., Ambat, R.
Publication date: 2009

Effects of gold coating on experimental implant fixation

Insertions of orthopedic implants are traumatic procedures that trigger an inflammatory response. Macrophages have been shown to liberate gold ions from metallic gold. Gold ions are known to act in an antiinflammatory manner by inhibiting cellular NF-kappa B-DNA binding and suppressing I-kappa B-kinase activation. The present study investigated whether gilding implant Surfaces augmented early implant osseointegration and implant fixation by its modulatory effect on the local inflammatory response. Ion release was traced by autometallographic silver enhancement. Gold-coated cylindrical porous coated Ti6Al4V implants Were inserted press-fit in the proximal part of tibiae in nine canines and control implants without gold inserted contralateral. Observation time was 4 weeks. Biomechanical push-out tests showed that implant,, with gold coating had decrease in mechanical strength and stiffness. Histomorphometrical analyses showed gold-coated implants had a decrease in overall total bone-to-implant contact of 35%. Autometallographic analysis revealed few cells loaded with gold close to the gilded implant surface. The findings demonstrate that gilding of implants negatively, affects mechanical strength and osseointegration because of a significant effect of the released gold ions on the local inflammatory process around the implant. The possibility that a partial metallic gold coating could prolong the period of satisfactory mechanical strength, however, cannot be excluded.

General information
Publication status: Published
Organisations: Department of Management Engineering
Pages: 274-280
Publication date: 2009
Electrochemical Migration on Electronic Chip Resistors in Chloride Environments

Electrochemical migration behavior of end terminals on ceramic chip resistors (CCRs) was studied using a novel experimental setup in varying sodium chloride concentrations from 0 to 1000 ppm. The chip resistor used for the investigation was 10-kΩ CCR size 0805 with end terminals made of 97Sn3Pb alloy. Anodic polarization behavior of the electrode materials was investigated using a microelectrochemical setup. Material makeup of the chip resistor was investigated using scanning electron microscopy (SEM)/energy dispersive spectroscopy and focused-ion-beam SEM. Results showed that the dissolution rate of the Sn and stability of Sn ions in the solution layer play a significant role in the formation of dendrites, which is controlled by chloride concentration and potential bias. Morphology, composition, and resistance of the dendrites were dependent on chloride concentration and potential.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Danish Technological Institute
Contributors: Minzari, D., Jellesen, M. S., Møller, P., Wahlberg, P., Ambat, R.
Pages: 392-402
Publication date: 2009
Peer-reviewed: Yes

Erosion–corrosion and corrosion properties of DLC coated low temperature

Low temperature nitriding of stainless steel leads to the formation of a surface zone of so-called expanded austenite, i.e. by dissolution of large amounts of nitrogen in solid solution. In the present work the possibility of using nitrogen expanded
austenite "layers" obtained by gaseous nitriding of AISI 316 as substrate for DLC coatings are investigated. Corrosion and erosion–corrosion measurements were carried out on low temperature nitrided stainless steel AISI 316 and on low temperature nitrided stainless steel AISI 316 with a top layer of DLC. The combination of DLC and low temperature nitriding dramatically reduces the amount of erosion–corrosion of stainless steel under impingement of particles in a corrosive medium.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Department of Management Engineering
Contributors: Jellesen, M. S., Christiansen, T., Hilbert, L. R., Møller, P.
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Wear
Volume: 06
Issue number: 038
ISSN (Print): 0043-1648
Ratings:
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.649 SNIP 2.047
Web of Science (2009): Indexed yes
Original language: English
Keywords: Stainless steel, DLC coatings, Erosion–corrosion, Expanded austenite
DOIs:
10.1016/j.wear.2009.06.038
Source: orbit
Source ID: 259228
Research output: Contribution to journal › Journal article – Annual report year: 2009 › Research › peer-review

Influence of bacteria on silver dissolution from silver-palladium surfaces

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Materials and Surface Engineering, FORCE Technology, University of Copenhagen
Contributors: Chiang, W., Hilbert, L. R., Schroll, C., Møller, P., Tolker-Nielsen, T.
Publication date: 2009

Host publication information
Title of host publication: European Corrosion Congress 2009
Source: orbit
Source ID: 253006
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2009 › Research

Silver-Palladium Surfaces Inhibit Biofilm Formation
Undesired biofilm formation is a major concern in many areas. In the present study, we investigated biofilm-inhibiting properties of a silver-palladium surface that kills bacteria by generating microelectric fields and electrochemical redox processes. For evaluation of the biofilm inhibition efficacy and study of the biofilm inhibition mechanism, the silver-sensitive Escherichia coli J53 and the silver-resistant E. coli J53[pMG101] strains were used as model organisms, and batch and flow chamber setups were used as model systems. In the case of the silver-sensitive strain, the silver-palladium surfaces killed the bacteria and prevented biofilm formation under conditions of low or high bacterial load. In the case of the silver-resistant strain, the silver-palladium surfaces killed surface-associated bacteria and prevented biofilm formation under conditions of low bacterial load, whereas under conditions of high bacterial load, biofilm formation occurred upon a layer of surface-associated dead bacteria.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Department of Systems Biology, Department of Management Engineering, University of Copenhagen
Contributors: Chiang, W., Schroll, C., Hilbert, L. R., Møller, P., Tolker-Nielsen, T.
Pages: 1674-1678
Unexpected corrosion of stainless steel in low chloride waters – microbial aspects

Abstract Stainless steels EN 1.4301 and 1.4404/1.4404 are normally considered corrosion resistant in low chloride natural waters like drinking water. However, a number of corrosion failures have been observed in e.g. fire extinguisher systems and drinking water installations, where stagnant conditions or periods of low water consumption have occurred prior to the failure. Typically the corrosion attacks appear within 2-3 years in weld nuggets, heat affected zones or in crevices like e.g. press fitting pipe connections. The failure mode is pitting and crevice corrosion leading to leaks and rust stains on the outside of the installation. Corrosion may occur in water qualities with rather low chloride contents and fairly low conductivity, which would usually not be considered especially corrosive towards stainless steel. One key parameter is the ennoblement documented on stainless steel in drinking water qualities, due to the formation of a biofilm. In itself, this is not enough to initiate pitting in these water qualities, but combined with a geometrically or metallurgically vulnerable area, corrosion may accelerate. The mechanism is linked to the naturally occurring microbial activity, where the localisation and growth of specific bacteria depend on the environment. Inside a crevice the oxygen content will decrease and anaerobic, stagnant conditions will form leading to growth of e.g. sulphate-reducing bacteria, whereas the heat tint on a heat affected zone with its high content of iron facilitates the growth of iron oxidising bacteria. A number of failure cases from Danish and Finnish stainless steel installations are discussed with the objective to identify key parameters, suggest possible mechanisms and discuss whether prediction is possible. The paper includes a short literature review, practical experience with corrosion in connections in stainless steel installations - either welded connections or press fittings - and suggested mechanisms for the microbiologically influenced corrosion of stainless steel in low chloride water. This cooperation was facilitated by COST D33 “Nanoscale electrochemical and bio-processes at solid-aqueous interfaces of industrial materials”.

AN ELECTROLYTIC CIP-CLEANING PROCESS FOR REMOVING IMPURITIES FROM THE INNER SURFACE OF A METALLIC CONTAINER

The invention relates to a novel electrolytic process for removing impurities from the inner surface of a metallic container. The process is particularly useful for cleaning process reactors used for culturing microorganisms, and storage tanks used for storing metabolites formed in the process reactor, as well as containers for dairy products.
A New Method to Inhibit Microbial and Biofilm Adhesions

Bacterial inhibiting surfaces caused by the effects of silver release and/or electrical field

In this study, silver-palladium surfaces and silver-bearing stainless steels were designed and investigated focusing on electrochemical principles to form inhibiting effects on planktonic and/or biofilm bacteria in water systems. Silver-resistant Escherichia coli and silver-sensitive E. coli were used for the evaluation of inhibiting effects and the inhibiting mechanism. For silver-palladium surfaces combined with bacteria in media, the inhibiting effect was a result of electrochemical interactions and/or electrical field, and in some specific media, such as ammonium containing, undesired silver ions release can occur from their Surfaces. For silver-bearing stainless steels, the inhibiting effect can only be explained by high local silver ions release, and can be limited or deactivated dependent on the specific environment. (c) 2008 Elsevier Ltd. All rights reserved.
Corrosion Reliability of Electronic Systems

Inherently two factors namely multi-material usage and potential bias makes electronic devices susceptible to corrosion if exposed to humid conditions. The problem is compounded today due to miniaturization and contamination effects. The reduction in size of the components and close spacing on a Printed Circuit Board (PCB) for high density packing has greatly increased the risk of corrosion under humid conditions. An important issue is the failures due to electrolytic metal migration. This paper describes an investigation of the electrolytic migration of Sn-Pb solder lines on PCBs in humid environments under applied potential conditions. Studies were carried out using two electrode potentiostatic polarization experiments and measuring the resulting current due to electrolytic migration. The surface morphology of the electrodes before and after migration testing was investigates using SEM and EDS. An in-service failure of a Ceramic Capacitor due to electrolytic migration in humid environments is also presented.

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Ambat, R., Jensen, S. G., Møller, P.
Pages: 17-28
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: ECS Transactions
Volume: 6
Issue number: 24
ISSN (Print): 1938-5862
Ratings:
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.254 SNIP 0.269
Original language: English
Electronic versions:
Stine.pdf
DOI:
10.1149/1.2900650
URL:
http://dx.doi.org/10.1149/1.2900650

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Influence of microstructure of 6063 aluminium alloy on the appearance of anodized layer

General information
Publication status: Published
Organisations: Manufacturing Engineering, Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Tabrizian-Ghalehno, N., Møller, P., Ambat, R., Hansen, H. N.
Publication date: 2008

Host publication information
Title of host publication: European Corrosion Congress 2008: Proceedings
Publisher: DEHEMA
Source: orbit
Source ID: 264281
Research output: Contribution to journal » Conference article – Annual report year: 2008 » Research » peer-review

Study of electroplated silver-palladium biofouling inhibiting coating
Biofouling can cause many undesirable effects in industrial and medical settings. In this study, a new biofouling inhibiting Ag-Pd surface was designed to form an inhibiting effect by itself. This design was based on silver combined with nobler palladium, both with catalytic properties. Owing to the potential difference between silver and palladium while contacting
with an electrolyte, the surface can form numerous discrete anodic and cathodic areas, so that an inhibiting reaction can occur. In this paper, a series of electrochemical and biological investigations were conducted to study the properties and biofouling inhibiting mechanism of these surfaces. In this study, the evidence is presented that the inhibiting effect can be caused by the electrochemical interactions and/or electric field between Pd and Ag/AgCl combined with an organic environment.

**Surface oxide formation during corona discharge treatment of AA 1050 aluminium surfaces**

Atmospheric plasmas have traditionally been used as a non-chemical etching process for polymers, but the characteristics of these plasmas could very well be exploited for metals for purposes more than surface cleaning that is presently employed. This paper focuses on how the corona discharge process modifies aluminium AA 1050 surface, the oxide growth and resulting corrosion properties. The corona treatment is carried out in atmospheric air. Treated surfaces are characterized using XPS, SEM/EDS, and FIB-SESEM and results suggest that an oxide layer is grown, consisting of mixture of oxide and hydroxide. The thickness of the oxide layer extends to 150–300 nm after prolonged treatment. Potentiodynamic polarization experiments show that the corona treatment reduces anodic reactivity of the surface significantly and a moderate reduction of the cathodic reactivity.

**General information**

Publication status: Published
Organisations: Materials and Surface Engineering, Department of Management Engineering, Solar Energy Programme, Risø National Laboratory for Sustainable Energy, Danish Technological Institute
Contributors: Minzari, D., Møller, P., Kingshott, P., Christensen, L. H., Ambat, R.
Pages: 1321-1330
Publication date: 2008
Peer-reviewed: Yes

**Publication information**

Journal: Corrosion Science
Volume: 50
Issue number: 5
ISSN (Print): 0010-938X
Ratings:
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.536 SNIP 2.306
Web of Science (2008): Indexed yes
Original language: English
Keywords: Oxide Coatings, XPS, Corona discharge treatment, Aluminium, Polarization
DOIs:
10.1016/j.corsci.2008.01.023
Tribocorrosion properties of metallic materials and effects of metal release

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering, Department of Manufacturing Engineering
Contributors: Jellesen, M. S., Hilbert, L. R., Møller, P.
Publication date: Dec 2007

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions:
mje_phd07_13nov2007.pdf
Source: orbit
Source ID: 271878

A New Approach for Biologically-Inhibiting Surfaces
A biologically-inhibiting surface based on electrochemical principles has been shown to have a reducing effect on the formation of biofilms in drinking water. The coating consists of silver and another precious metal, which is applied to the surface in small areas with a thickness measured in nanometers. Due to the difference in potentials, the biologically-inhibiting material will act as a galvanic element in contact with an electrolyte. The electrochemical processes taking place at the metal surface seem to exhibit a catalytic oxidation character more than an oligomeric effect from the silver.

General information
Publication status: Published
Organisations: Department of Management Engineering, Department of Environmental Engineering
Contributors: Møller, P., Hilbert, L. R., Corfitzen, C. B., Albrechtsen, H.
Pages: 149-157
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Journal of Applied Surface Finishing
Issue number: 2
ISSN (Print): 1559-9590
Original language: English
Keywords: Biological inhibition, Silver
Source: orbit
Source ID: 202431
Research output: Contribution to journal › Journal article – Annual report year: 2007 › Research › peer-review

Complex process chains for manufacturing of invisible displays integrated in bulk metal panels

General information
Publication status: Published
Organisations: Department of Management Engineering, Bang & Olufsen A/S
Contributors: Hansen, H. N., Prichystal, J., Møller, P., Bladt, H. H.
Pages: 237-240
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Annals of CIRP
Volume: 56/1
ISSN (Print): 0007-8506
Ratings:
Scopus rating (2007): SJR 1.119 SNIP 1.495
Corrosion investigation of material combinations in a mobile phone dome-key pad system

Mobile phone dome-key pad system is the device that connects the phone keys to the printed circuit board (PCB). The material combination for a typical dome-key pad system is Ag/AISI 202 steel for the dome and Au/Ni/Cu for the key pad. Under humid conditions dome-key pad system is susceptible to multiple corrosion problems. In this paper, the corrosion susceptibility of dome (Ag/AISI 202 steel) and key pad system (Au/Ni/Cu) is investigated with an aim to understand the corrosion performance of such multi-material combinations in chloride containing environment. Investigation includes microstructural studies, polarization measurements using microelectrochemical technique, salt spray testing, and corrosion morphology analysis. The immersion Au layer on pads showed pores, and rolled bonded silver layer on dome had cracks and kinks. The difference in electrochemical behaviour of the metallic layers together with imperfections in the top layer results in severe pitting due to galvanic coupling. However, corrosion performance of the pads was much worse than domes. The results are applicable to a broad spectrum of PCB parts where similar material combinations are employed, especially Au/Ni/Cu.

In-situ Investigation of Lead-free Solder Alloy Formation Using a Hot-plate Microscope

This work presents the advantages of using a hot-plate microscope for investigation of new (high-temperature) lead-free solders as in-situ analysis tool and preparation equipment. A description of the equipment and the preparation method is given and some examples are outlined. The formation of small AuSn-based, homogeneous and un-oxidized solder spheres will be demonstrated. Moreover the possibility of using this equipment as a sample preparation method to further investigation is shown. As example the equipment was used to produce samples for Vickers microhardness measurement of important phases of the Au-Sn system. The measured values are comparable to those found in the literature. An outlook to further research is also given.

General information
Publication status: Published
Organisations: Materials and Surface Engineering, Department of Mechanical Engineering
Contributors: Ambat, R., Møller, P.
Pages: 2866-2879
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Corrosion Science
Volume: 49
Issue number: 7
ISSN (Print): 0010-938X
Ratings:
Scopus rating (2007): SJR 1.51 SNIP 1.998
Web of Science (2007): Indexed yes
Original language: English
Keywords: Electronic materials, Microelectrochemistry, Metal coatings, Galvanic corrosion
DOIs:
10.1016/j.corsci.2006.12.013
Source: orbit
Source ID: 210110
Research output: Contribution to journal > Journal article – Annual report year: 2007 > Research > peer-review

In-situ Investigation of Lead-free Solder Alloy Formation Using a Hot-plate Microscope

This work presents the advantages of using a hot-plate microscope for investigation of new (high-temperature) lead-free solders as in-situ analysis tool and preparation equipment. A description of the equipment and the preparation method is given and some examples are outlined. The formation of small AuSn-based, homogeneous and un-oxidized solder spheres will be demonstrated. Moreover the possibility of using this equipment as a sample preparation method to further investigation is shown. As example the equipment was used to produce samples for Vickers microhardness measurement of important phases of the Au-Sn system. The measured values are comparable to those found in the literature. An outlook to further research is also given.

General information
Publication status: Published
Organisations: Department of Management Engineering, Institute for Product Development
Contributors: Bergmann, R., Tang, P. T., Hansen, H. N., Møller, P.
Publication date: 2007

Host publication information
Title of host publication: Proceedings of the 9th IEEE Electronics Packaging Technology Conference
Publisher: IEEE
Micro-electrochemical machining of aluminium

General information
Publication status: Published
Organisations: Department of Management Engineering, Manufacturing Engineering, Department of Mechanical Engineering, Materials and Surface Engineering
Contributors: Prichystal, J., Hansen, H. N., Møller, P., Luca, M., Bladt, H. H.
Publication date: 2007

Host publication information
Title of host publication: Proceedings ISEM XV - International symposium on electromachining
Place of publication: Nebraska
Publisher: University of Nebraska-Lincoln
ISBN (Print): 09-79-49771-X
Source: orbit
Source ID: 210251
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2007 › Research › peer-review

Pulse Reversal PermAlloy Plating Process for MEMS Applications
Nickel-iron, and especially Permalloy, plating has been known and used for more than 40 years, but there are still several problems related to stability and maintenance that should be resolved. This paper presents a saccharine-free pulse reversal plating Permalloy electrolyte, which gives low-stress deposits. We demonstrate selected MEMS applications of the electrolyte. The use of the strong complexing agent 5-sulfosalicylic acid allows for a photometric determination of the Fe3+ level in the bath and eliminate precipitates. This makes the electrolyte suitable as a Permalloy plating process used on an irregular basis.

General information
Publication status: Published
Organisations: Department of Micro- and Nanotechnology, Department of Management Engineering
Contributors: Smistrup, K., Tang, P. T., Møller, P.
Pages: 179-189
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: ECS Transactions
Volume: 3
Issue number: 25
ISSN (Print): 1938-5862
Ratings:
Scopus rating (2007): SJR 0.213 SNIP 0.225
Original language: English
Electronic versions:
Tang.pdf
DOIs:
10.1149/1.2753252
URLs:
http://dx.doi.org/10.1149/1.2753252
Study of electroplated silver-palladium biofouling inhibiting coating
The undesired microbial and biofilm adhesions on the surfaces of food industrial facilities, water supply systems and etc. are so called as “biofouling”. Biofouling can cause many undesirable effects. Until now for solving biofouling, there are few non-toxic inhibiting treatments. In this study, a new coating has been designed to form an inhibiting effect on the surface by itself. In this way, it is desired that the release of any matter will be in low concentration. This design is based on silver combined with nobler palladium, both with catalytic properties. Due to the potential difference between silver and palladium while contacting with an electrolyte, the surface can form numerous discrete anodic and cathodic areas, so that an inhibiting reaction can be formed. In this paper, a series of electrochemical and biological tests were conducted to study the properties of these surfaces. The inhibiting mechanism is discussed as well.

Corrosion and Environmental Effects on Electronic Systems

Corrosion of Steel in Concrete, Part I – Mechanisms
Throughout the world reinforced concrete is the most widely used construction material for buildings and civil engineering structures. Most reinforced concrete structures have performed satisfactory over many decades, but there still is an unacceptable large number of structures that deteriorate prematurely. Reinforcement corrosion is identified to be the foremost cause of deterioration. Steel in concrete is normally protected by a passive layer due the high alkalinity of the concrete pore solution; corrosion is initiated by neutralization through atmospheric carbon dioxide and by ingress of depassivation ions, especially chloride ions. The background and consequences of deterioration of reinforced concrete structures caused by steel corrosion are summarized. Selected corrosion mechanisms postulated in the literature are briefly discussed and related to observations. The key factors controlling initiation and propagation of corrosion of steel in concrete are outlined.
Corrosion of steel reinforcement in concrete, Part II - Non-destructive testing

Erosion-corrosion behaviour of innovative hardening treatments

Erosion-corrosion behaviour of innovative hardening treatments and coatings on stainless steels for food industry applications.
Establishment of integrated information displays in aluminium surfaces using nanomanufacturing
Bang & Olufsen has been working with a method for manufacturing ultra-thin structures in aluminium that can be penetrated by light. This work has resulted in a patent describing how to obtain this effect by material removal in local areas in a solid material. The idea behind an invisible display in aluminium concerns the processing of a metal workpiece in such a way that microcavities are formed from the backside of the workpiece. The microcavities must not penetrate the metal front side, but an ultra-thin layer of metal is left. It is possible to shine light through this layer. By ordering microcavities in a matrix, different symbols can be obtained by shining light from the backside of the workpiece. When there is no light from the backside, the front surface seems totally untouched. Three different manufacturing processes were investigated to achieve the desired functionality: laser micromachining with ultra-short pulses, selective etching combined with anodizing, and electrochemical machining.

General information
Publication status: Published
Organisations: Department of Management Engineering, Bang & Olufsen A/S
Contributors: Prichystal, J., Hansen, H. N., Bladt, H. H., Møller, P.
Pages: 151-156
Publication date: 2006
Peer-reviewed: Yes

Publication information
Volume: 220
Issue number: 3
ISSN (Print): 1740-3499
Ratings:
Scopus rating (2006): SJR 0.14 SNIP 0.034
Original language: English
DOIs:
10.1243/17403499JNN89
Source: orbit
Source ID: 210253
Research output: Contribution to journal › Journal article – Annual report year: 2007 › Research › peer-review

Local residue detection tool for measuring conductive residue levels on printed circuit boards

General information
Publication status: Published
Organisations: Department of Systems Biology, Materials and Surface Engineering, Department of Mechanical Engineering, Department of Management Engineering
Contributors: Westermann, P., Ambat, R., Møller, P.
Publication date: 2006
Peer-reviewed: No
Event: Poster session presented at Annual meeting of the Danish Electrochemical Society, Copenhagen, .
Source: orbit
Source ID: 195045
Research output: Contribution to conference › Poster – Annual report year: 2006 › Research

Management of Reinforcement Corrosion

General information
Publication status: Published
Organisations: Section for Construction Materials, Department of Civil Engineering, Department of Management Engineering
Contributors: Küter, A., Geiker, M. R., Møller, P.
Publication date: 2006
Peer-reviewed: No
Event: Poster session presented at Nanocem Spring Meeting 2006, Copenhagen, Denmark, .
Source: orbit
Source ID: 193133
Microstructure and thermal stability of nickel layers electrodeposited from an additive-free sulphamate-based electrolyte
The influences of the current density and the temperature on the microstructure and hardness of Ni layers electrodeposited from an additive-free sulphamate bath were investigated. The microstructure and thermal stability of the electrodeposits was investigated with a combination of transmission and scanning electron microscopy and X-ray diffraction; the Vickers hardness was measured in cross sections. The present is meant as a reference for forthcoming articles on the investigation of various strengthening mechanisms on the microstructure, hardness and thermal stability of Ni (alloys) electrodeposits.

General information
Publication status: Published
Organisations: Institute for Product Development, Department of Management Engineering
Contributors: Rasmussen, A. A., Møller, P., Somers, M. A. J.
Pages: 6037-6046
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Surface and Coatings Technology
Volume: 200
Issue number: 20-21
ISSN (Print): 0257-8972
Ratings:
Scopus rating (2006): SJR 1.282 SNIP 1.725
Web of Science (2006): Indexed yes
Original language: English
Source: orbit
Source ID: 198595
Research output: Contribution to journal › Journal article – Annual report year: 2006 › Research › peer-review

Nickel-containing coins: a health risk for nickel-sensitive individuals?

General information
Publication status: Published
Organisations: Department of Management Engineering, Copenhagen University Hospital
Contributors: Jellesen, M. S., Hilbert, L. R., Møller, P., Ménne, T.
Pages: 1301
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: British Journal of Dermatology
Volume: 155
Issue number: 6
ISSN (Print): 0007-0963
Ratings:
Scopus rating (2006): SJR 1.866 SNIP 2.835
Web of Science (2006): Indexed yes
Original language: English
Source: orbit
Source ID: 193898
Research output: Contribution to journal › Journal article – Annual report year: 2006 › Research › peer-review

Paradigm shift for PWD surface finishes in mobile phone terminals

General information
Publication status: Published
Organisations: Institute for Product Development, Department of Management Engineering, Nokia Danmark A/S
Contributors: Nielsen, C., Rasmussen, A. A., Ambat, R., Møller, P.
Publication date: 2006

Host publication information
Pulse Reversal PermAlloy Plating Process for MEMS Applications

General information
Publication status: Published
Organisations: Department of Micro- and Nanotechnology, Department of Management Engineering
Contributors: Smistrup, K., Tang, P. T., Møller, P.
Pages: Abstract 1673
Publication date: 2006

Host publication information
Title of host publication: Meeting Abstracts - Electrochemical Society
Publisher: The Electrochemical Society
Electronic versions: Møller.pdf

Bibliographical note
Copyright The Electrochemical Society, Inc. [2006]. All rights reserved. Except as provided under U.S. copyright law, this work may not be reproduced, resold, distributed, or modified without the express permission of The Electrochemical Society (ECS).

Selective anodising technologies for obtaining translucent micro structures
Anodising of aluminium is a well-known technology usually applied to surface treatment. With this technology a transparent layer of oxide is established on the surface of a workpiece. For the establishment of components in aluminium with certain light transmitting areas anodising was investigated. A process sequence involving application of photoresist, lithography using UV light, development of photoresist and subsequent anodising was established and investigated. The effect of various process parameters, material composition as well as pattern layout on the final component quality was investigated. It was found that with this technology it is possible to create light transmitting areas on aluminium workpieces consisting of either dot-like structures or continuous patterns.

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Hansen, H. N., Møller, P., Jamov, C., Staun, J., Prichystal, J. P.
Pages: 175-180
Publication date: 2006

Host publication information
Title of host publication: Towards synthesis of micro-/nano systems
Publisher: Springer
Editor: Kimura, F.
ISBN (Print): 1-84628-558-5
Source: orbit
Source ID: 194574
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2006 › Research › peer-review

Setup for combined electrochemical and friction testing during sliding wear

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Jellesen, M. S., Hansen, M. Ø., Hilbert, L. R., Møller, P.
Number of pages: 16
Studies on tribocorrosion explain low nickel release

The electrochemical behaviour of innovative hardening treatments and coatings on stainless steels exposed to erosive-corrosive conditions in the food industry

The virtual classroom
Corrosion of Steel in Concrete – Potential Monitoring and Electrochemical Impedance Spectroscopy during Corrosion Initiation and Propagation

A reinforced mortar specimen that allows potential measurements and electrochemical impedance spectroscopy (EIS) immediately after preparation was designed and tested. The specimen consists of a mortar cylinder with a central rebar and a concentric arrangement of embedded Ru/Ir activated titanium wires. The wires can act as both reference and counter electrode during EIS and, thus, no external electrode is required. The defined geometry solves reproducibility problems involved with application of an external reference electrode for EIS. Changes of the electromotive force (EMF) between rebar and titanium wires can be monitored immediately after preparation. The wire arrangement also allows investigation of local changes in the bulk mortar by EIS or by measuring the potential development of the titanium wires versus an external standard electrode. The specimen design was evaluated in an investigation on the effect of the steel quality and the steel surface properties on initiation and propagation of chloride-induced reinforcement corrosion. Besides untreated (as received) carbon rebars and stainless rebars, selected surface treatments and galvanization were investigated. The surface treatments included grit blasting, electrochemical and hydrochloric acid cleaning (HCl) as well as weathering. The results indicate that the investigated treatments of the carbon steel surface have no major effect on the initiation period, which was approximately 20 days under the actual conditions. The galvanized rebar appears to be protected throughout the experimental period to date (200 days), whereas active corrosion of the stainless steel appeared to be initiated after 100 days exposure.

Corrosion of Steel in Concrete – Specimen Design for Investigation of Interface and Bulk Conversions during Curing and Exposure

A reinforced mortar specimen that allows electromotive force (EMF) measurements and electrochemical impedance spectroscopy (EIS) was designed and tested. The specimen consists of a mortar cylinder with a central rebar and a concentric arrangement of embedded electrode wires. The wires can act as both reference and counter electrode during EIS and the arrangement allows investigation of local changes in the bulk mortar by measuring the EMF of each wire versus an external standard electrode. The state of corrosion of the rebar can be investigated by EIS and EMF. EIS can be performed before submersion as external electrodes are not required. Qualitative changes of the EMF between the internal electrodes and the rebar can also be monitored immediately after preparation.
Effect of Guard Ring Arrangements on the Current Confinement and Polarisation of steel in concrete - Experiments and Modeling

General information
Publication status: Published
Organisations: Section for Building Materials and Geotechnics, Department of Civil Engineering, Department of Management Engineering, FORCE Technology
Contributors: Nygaard, P. V., Møller, P., Sørensen, H. E., Geiker, M. R., Klinghoffer, O.
Publication date: 2005

Host publication information
Title of host publication: Eurocorr 2005 - Book of abstracts
ISBN (Print): 972-95921-1-x
Source: orbit
Source ID: 183497

Korrelation Prozeß - Gefüge - Eigenschaften

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Pantleon, K., Tang, P. T., Rasmussen, A. A., Mizushima, I., Jensen, J. D., Møller, P., Somers, M. A.
Publication date: 2005

Host publication information
Title of host publication: Proceedings of 6. Industriefachtagung "Oberflächen- und Wärmebehandlungstechnik"
URLs:
http://www.ipl.dtu.dk/publikation/9057/dk/
Source: orbit
Source ID: 187776

New trends for PWB surface finishes in mobile phone applications
Immersion Ni/Au has been the overall dominant surface finish on PWB's for the last 10 years. During the last 5 years Mobile Phones have been extremely popular and spread all over the world in different climate zones in very high volumes. At the same time the Mobile Phone terminal for many people has become a necessity that is brought with them in any activity they practice. These changes in user behaviour have heavily changed the impact from moisture, sweat, corrosive atmospheres and mechanical drop. As a result of this the requirement to solder joint reliability, corrosion stability and wear resistance are heavily increasing to keep a high reliability of the terminal. A paradigm shift to avoid use of Immersion Ni/Au is ongoing nowadays because the thin and porous Imm. Ni/Au can't address these challenges in a satisfactory way. Already some years ago OSP has replaced Immersion Ni/Au on solder pads in terminals from Nokia with positive impact on solder joint reliability. Theoretical electrochemical studies, experimental work and full scale high volume production has now demonstrated that Carbon surface finish for Key- and spring contact-pads, combined with the right concept design will make use of Imm. Ni/Au unnecessary in the near future. The end result is higher reliability with less expensive and simpler processes. This paper will discuss the various considerations for choice of surface finish and results from the extensive feasibility studies performed by Nokia Mobile Phones, supplemented by theoretical electrochemical studies performed by IPU/DTU.

General information
Publication status: Published
Organisations: Department of Management Engineering, Nokia Danmark A/S
Contributors: Nielsen, C. W., Ambat, R., Rasmussen, A. A., Møller, P.
The electrochemical deposition of tin-nickel alloys and the corrosion properties of the coating

The electrodeposition of tin/nickel (65/35 wt%) is a unique coating process because of the deposition of an intermetallic phase of nickel and tin, which cannot be formed by any pyrometallurgical process. From thermodynamic calculations it can be shown that intermetallic phases can be formed through electrodeposition. The alloy has unique corrosion properties and exhibits surface passivation like stainless steel. The coating is decorative and non-allergic to the skin, can replace decorative nickel and nickel-chromium coatings in many cases and decreases the risk for allergic contact dermatitis. A number of electrochemical tests, including polarization curves, chronoamperometric studies and tribocorrosion tests have been performed to show the consequence of replacing nickel coatings with tin/nickel coatings.
CASE-HARDENING OF STAINLESS STEEL
The invention relates to case-hardening of a stainless steel article by means of gas including carbon and/or nitrogen, whereby carbon and/or nitrogen atoms diffuse through the surface into the article. The method includes activating the surface of the article, applying a top layer on the activated surface to prevent repassivation. The top layer includes metal which is catalytic to the decomposition of the gas.

General information
Publication status: Published
Organisations: Department of Manufacturing Engineering, Department of Management Engineering
Contributors: Somers, M. A. J., Christiansen, T., Møller, P.
Publication date: 2004

Publication information
Patent number: WO2004007789
Filing date: 22/01/2004
Original language: English

Bibliographical note
International application published under the World Intellectual Property Organization (WIPO)
Source: orbit
Source ID: 25821
Research output: Patent › Patent – Annual report year: 2004 › Research

Corrosion of steel in concrete: Thermodynamical aspects

General information
Publication status: Published
Organisations: Section for Building Materials and Geotechnics, Department of Civil Engineering, Department of Management Engineering
Contributors: Küter, A., Geiker, M. R., Møller, P.
Publication date: 2004

Host publication information
Title of host publication: Proceeding of 13th Scandinavian Corrosion Congress
Source: orbit
Source ID: 132361
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2004 › Research

Corrosion of Steel in Concrete – Thermodynamical Aspects
The present understanding of selected corrosion phenomena in reinforced concrete is reviewed. Special emphasis is given to chloride induced corrosion. There is a general acceptance of the basic corrosion mechanism for steel in concrete. However different anodic reactions governing the subsequent formation and composition of corrosion products have been proposed. Suggested reactions, except half-cell reactions, are verified or rejected based on their Gibbs free energy, while the electrode potential is calculated for half-cell reactions. Corrosion products postulated to form are related to observations. A thermodynamically possible reaction mechanism for the formation of green rust in the presence of chlorides is proposed. Initial verification of the suggested mechanism is given based on experimental data from the literature and own observations.

General information
Publication status: Published
Organisations: Section for Building Materials and Geotechnics, Department of Civil Engineering, Department of Management Engineering
Contributors: Küter, A., Møller, P., Geiker, M. R.
Number of pages: 46
Publication date: 2004

Host publication information
Title of host publication: 13. Scandinavian Corrosion Congress : Abstracts
Place of publication: Reykjavic, Iceland
Publisher: The Icelandic Building Research Insitute
Innovative materials solutions through classical technology?

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Møller, P., Somers, M. A.
Pages: 53-61
Publication date: 2004

**Host publication information**
Title of host publication: BRIDGING from Technology to Society : DTU 1829-2004 - 175 år
Place of publication: Kgs.Lyngby
Publisher: Technical University of Denmark (DTU)
Editors: Stubkjær, K., Kortenbach, T.
ISBN (Print): 87-990378-0-7
Source: orbit
Source ID: 177923

Acoustic streaming enhanced electrodeposition of nickel

Electrochemical deposition of Ni from a Watts-type electrolyte under the influence of high frequency ultrasound at both high (250 W) and low (5–10 W) power sonication was investigated. An improvement in the material distribution of the deposited Ni in millimeter-sized groove-features on the cathode surface was observed. A theory based on mechanical interaction between organic additives adhering to the cathode surface and ultrasonically induced streaming-phenomena is presented here to account for the observed uniform filling behaviour. The present study further indicates a correlation between fringe-patterns on the surface of the deposit and near-boundary acoustic streaming.

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Jensen, J. D., Møller, P.
Pages: 732-737
Publication date: 2003
Peer-reviewed: Yes

**Publication information**
Journal: Chemical Physics Letters
Volume: 368
Issue number: 5-6
ISSN (Print): 0009-2614
Ratings:
Scopus rating (2003): SJR 1.639 SNIP 1.169
Web of Science (2003): Indexed yes
Original language: English
DOI:
10.1016/S0009-2614(02)01917-6
URLs:
http://www.ipl.dtu.dk/publikation/6985/dk/
Source: orbit
Source ID: 63088

Creation of Micro Products in the future - joining of materials as a key technology

The use of micro products and micro components has been strongly increasing through the past 5 years. Market surveys predict that the world market will increase from approximately 30 billion USD in 2000 to 60 billion USD in 2005 (ref.1-2). The most important product groups are IT components (ink jet printers, reading caps for hard disks etc.) as well as medical and biomedical products (pacemakers, analysis equipment, sensors etc.). Furthermore motion sensors for the
automotive industry represent an industrial application of micro systems. On the technological side the development has moved very fast, primarily driven by the need of the electronics industry to create still smaller chips with still larger capacity. Therefore the manufacturing technologies connected with micro/nano products in silicon are relatively highly developed compared to the technologies used for manufacturing products in metals, polymers and ceramics (ref.3).

Electrochemical deposition of buried contacts in high-efficiency crystalline silicon photovoltaic cells
This article reports on a newly developed method for electrochemical deposition of buried Cu contacts in Si-based photovoltaic -PV- cells. Contact grooves, 20 mm wide by 40 mm deep, were laser-cut into Si PV cells, hereafter applied with a thin electroless NiP base and subsequently filled with Cu by electrochemical deposition at a rate of up to 10 mm per min. With the newly developed process, void-free, superconformal Cu-filling of the laser-cut grooves was observed by scanning electron microscopy and focused ion beam techniques. The Cu microstructure in grooves showed both bottom and sidewall texture, with a grain-size decreasing from the center to the edges of the buried Cu contacts and a pronounced lateral growth outside the laser-cut grooves. The measured specific contact resistances of the buried contacts was better than the production standard. Overall performance of the new PV cells was equal to the production standard with measured efficiencies up to 16.9%.
A PROCESS FOR DEPOSITING METAL CONTACTS ON A BURIED GRID SOLAR CELL AND A SOLAR CELL OBTAINED BY THE PROCESS

A buried grid solar cell is manufactured by a process for metallising one or more metal contacts of a buried grid solar cell having a body of doped semiconductor material, wherein the electrical contact(s) is/are provided by conducting material being arranged in a pattern of one or more grooves into the semiconductor material with the following steps: applying a seed layer on the exposed semiconductor material in the grooves by elecroless plating followed by sintering, applying an electrically conducting base layer by electroless plating on top of said seed layer and filling the grooves with an electrically conducting contact forming material by electrolytic plating using a conventional electrolytic bath further comprising a levelling additive and a suppressing additive and using substantially constant cell voltage.

General information
Publication status: Published
Organisations: Department of Manufacturing Engineering, Institute for Product Development
Contributors: Jensen, J. A. D., Møller, P., Mason, N. B., Russel, R. W. J., Verhoeven, P.
Publication date: 2002

Publication information
Patent number: WO2002015282
Filing date: 21/02/2002
Original language: English

Bibliographical note
International application published under the World Intellectual Property Organization (WIPO)
Source: orbit
Source ID: 177656
Research output: Patent – Annual report year: 2002 › Research

Comparison of adhesion of the food spoilage bacterium Shewanella putrefaciens to stainless steel and silver surfaces

The aim of this study is to compare the number of attached bacteria, Shewanella putrefaciens, on stainless steel with different silver surfaces. Thus evaluating if silver surfaces could contribute to a higher hygienic status in the food industry. Bacterial adhesion to three types of silver surfaces (new silver, tarnished silver and sulphide treated silver) was compared to adhesion to stainless steel (AISI 316). Numbers of attached bacteria (cfu cm-2) were estimated using the Malthus indirect conductance method. A lower number of attached bacteria were measured on new silver surfaces compared to stainless steel for samples taken after 24 hours. However this was not significant (P > 0.05). The numbers of attached bacteria were consistently lower when tarnished silver surfaces were compared to stainless steel and some, but not all, experiments showed statistically significant. A difference of more than one log unit in bacterial numbers on the two types of materials was observed, but for most samples the difference was within one log unit. Treating new silver with sulphide to try to reproduce a tarnished silver surface did not result in a similar lowering of adhering cells when compared to steel (P > 0.05). To conclude new or tarnished silver surfaces caused a slight reduction in numbers of attached bacteria, however, the difference was only sometimes statistically different.

General information
Publication status: Published
Organisations: Department of Management Engineering, National Food Institute, Division of Industrial Food Research, National Institute of Aquatic Resources
Contributors: Hjelm, M., Hilbert, L. R., Møller, P., Gram, L.
Pages: 903-911
Publication date: 2002
Peer-reviewed: Yes

Publication information
Journal: Journal of Applied Microbiology
Volume: 92
Issue number: 5
ISSN (Print): 1364-5072
Ratings:
Web of Science (2002): Indexed yes
Original language: English
Keywords: Corrosion
DOIs: 10.1046/j.1365-2672.2002.01609.x
Source: orbit
Source ID: 63200
Electrodeposition of CuInSe₂

General information
Publication status: Published
Organisations: Department of Photonics Engineering, Diode Lasers and LED Systems, Department of Mechanical Engineering, Materials and Surface Engineering, Technical University of Denmark
Contributors: Lindberg, M., Poulsen, P. B., Møller, P.
Number of pages: 2
Publication date: 2002
Peer-reviewed: Yes
Electronic versions: pub_127.pdf

Bibliographical note
Source: PublicationPreSubmission
Source ID: 117015154

Influence of 1,3,6 naphthalene trisulfonic acid on microstructure & hardness in electrodeposited Ni-layers
The influence of the additive 1,3,6 naphthalene trisulfonic acid on the microstructure and hardness of electrodeposited nickel layers was investigated. The microstructure was characterized using transmission electron microscopy; the Vickers hardness was measured in cross sections. The additive was found to refine the grain size resulting in and enhanced hardness. The efficiency of the additive in enhancing the hardness was found to depend on the current density during deposition.

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Rasmussen, A. A., Møller, P., Somers, M. A. J.
Pages: 46-49
Publication date: 2002
Peer-reviewed: Yes

Microstructure & Other Properties of Pulse-Plated Copper for Electroforming Applications
Microstructure, hardness, material distribution and current efficiency were studied for various pulse patterns (both direct current, on/off and pulse reverse plating) and different bath compositions of copper sulfate and sulfuric acid, with additions of chloride. The objective was to develop a reliable copper electroforming process to provide a fine-grained and hard (above HV 125) deposit with good micro- and macrothrowing power. Potential applications include solar cell panels, tools for micro injection molding and various microelectromechanical systems (MEMS).

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Tang, P. T., Jensen, J. D., Dam, H., Møller, P.
Publication date: 2002

Host publication information
Magnetoelastic Transducer Materials - a Plateable Possibility

A short presentation of the magnetostriction theory as well as a series of possible applications for magnetoelastic transducers are given. A review of the present state of development for these materials is discussed with relation to the various ways of manufacture. The paper is concluded with the presentation of a method for making magnetoelastic materials by electrochemical deposition (electroless) as tried by the authors in collaboration with the Daimler-Chrysler research centre in Ulm, Germany. First results of this work are both promising and intriguing: Sensitivities of the same order as the reference material Terfenol-D were obtained, but reproduction of exact magnetic properties is still critical with the new plating technique.

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Jensen, J. D., Møller, P.
Publication date: 2001
Electroplating and Characterisation of Zinc Composite Coatings

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Fontenay, Andersen, L. B., Møller, P.
Publication date: 2000

Host publication information
Title of host publication: Electroplating and Characterisation of Zinc Composite Coatings
URLs:
http://www.ipl.dtu.dk/publikation/461/dk/
Source: orbit
Source ID: 186766
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2000 › Research › peer-review

Fabrication of Microcomponents by Electrochemical Manufacturing: Advanced Feed-Through Metallisation on Silicon and Nickel Micromechanical Resonators

Electrochemical processes such as electroplating, wet selective etching (or controlled corrosion) and electroless plating are powerful tools for fabrication of MEMS (Micro ElectroMechanical Systems) products. Especially when the electrochemical processes are used in combination with UV-lithography, silicon substrates and other processes traditionally associated with microelectronics. By replacing ceramic materials, in some parts of a MEMS structure, with metal - and introducing electrochemical manufacturing - the production costs can be significantly reduced. This will be illustrated by two very different MEMS component examples: An example uses electrochemical manufacturing to form multiple feed-though wires of copper (similar to printed circuit boards, but much smaller and on tree-dimensional surfaces) from one side of a silicon wafer to the other. In this example tin bumps for flip-chip bonding, as well as nickel/gold pads for conductive adhesive bonding, are also deposited by electroplating. The second example is a simple, inexpensive, low-temperature electroplating process for fabrication of released, stress-free nickel comb resonators. Since the manufacturing sequence only involves low-temperature steps, it is well suited for post processing on CMOS devices. The resonators have been tested using optical readout, and quality factors of around 550 have been measured in an atmospheric ambient.

General information
Publication status: Published
Organisations: Department of Management Engineering, Department of Micro- and Nanotechnology, Micoreactors
Contributors: Tang, P. T., Heschel, M., Ravnikilde, J. T., Hansen, O., Møller, P., Alting, L.
Publication date: 2000
Host publication information
Title of host publication: 1st euspen topical conference on Fabrication and Metrology in Nanotechnology
Publisher: IPL
URLs:
http://www.ipl.dtu.dk/publikation/467/dk/
Source: orbit
Source ID: 186772
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2000 › Research › peer-review

Materialeteknologi - samfundets udviklingsgrundlag

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Møller, P., Somers, M. A.
Pages: 10-12
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: Produktions Nyt
Volume: 38 #03
Original language: Danish
URLs:
http://www.ipl.dtu.dk/publikation/428/dk/
Source: orbit
Source ID: 186746
Research output: Contribution to journal › Journal article – Annual report year: 2000 › Research › peer-review

An Electroplating Method of Forming Platings of Nickel, Cobalt, Nickel Alloys and Cobalt Alloys with Reduced Stress

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Tang, P. T., Dylmer, H., Møller, P.
Number of pages: 6
Publication date: 1999

Publication information
Publisher: European Patent Office
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7758/dk/
Source: orbit
Source ID: 187279
Research output: Book/Report › Report – Annual report year: 1999 › Research › peer-review

Electron transport and two-dimensional organisation of metalloprotein adsorbates investigated by cyclic voltammetry and in situ scanning tunnelling and atomic force microscopy

General information
Publication status: Published
Organisations: Department of Chemistry
Contributors: Friis, E. P., Andersen, J. E. T., Møller, P., Thuesen, M. H., Andersen, N. H., Ulstrup, J.
Pages: 133-160
Publication date: 1999

Host publication information
Title of host publication: Comprehensive Chemical Kinetics, R.G. Compton
Place of publication: Amsterdam
Publisher: Elsevier
**A New cell design for Potentiostatically Controlled In Situ Atomic Force Microscopy**

We describe the design and construction of a new type of AFM cell for in situ imaging under potentiostatic control. The cell is specifically designed for a Rasterscope 4000TM AFM instrument with no need for instrumental modification, but can easily be adapted to other commercial instruments. The cell is a closed system with insignificant sample evaporation. It is a chemically and mechanically robust two-component system which enables fast assembly and testing prior to insertion and minimizes leakage problems. The cell is also laterally flexible, facilitating scanning of large areas, holds inlets for rapid flushing and change of solution, and contains an optical device for adjusting the laser beam deflection in aqueous and gas ambient environments. Cyclic voltammetry of a simple redox couple and combined cyclic voltammetry and in situ AFM of copper deposition/ dissolution cycles testify to perfect cell performance.

**Dynamic of Pseudomonas aeruginosa azurin and its Cys3Ser mutant at single-crystal gold surfaces investigated by cyclic voltammetry and atomic force microscopy**

**Metalloprotein Adsorption on Au(111) and Polycrystalline Platinum Investigated by In Situ Scanning Tunnelling Microscopy with Molecular and Sub-Molecular Resolution**

Redox metalloproteins exhibit interesting features such as long-range electron transfer (ET), cooperative effects etc. of importance in relation to fundamental ET theory, and mapped in considerable detail. Adsorption and interfacial electrochemical ET of metalloproteins at metallic surfaces is also broadly important in a range of contexts, and has been addressed by spectroscopic, voltammetric, and thermodynamic methods. In situ scanning tunneling (STM) and atomic
force microscopy (AFM) have opened new perspectives for addressing adsorbed metalloproteins in their natural functional aqueous medium at the molecular level. In addition to broadly recognized problems of in situ STM/AFM imaging, sample preparation, mobility, and adsorbate stability are, however, particular problems. We illustrate here the perspectives by recent in situ STM imaging of covalently bound horse heart cytochrome c on polycrystalline platinum, and of chemisorbed Pseudomonas aeruginosa azurin on Au(111). Molecular resolution is achieved, but azurin gives by far the best images which show, moreover, an interesting submolecular feature. This is likely to be associated with the disulphide group as a natural unit for gentle linking, facile ET routes through the protein, and tunnel enhancement by the low-lying redox level of the copper atom. The particular electronic-vibrational three-level configuration in in situ STM of metalloproteins offers a new way of distinction between superexchange, coherent, and sequential ET modes in the long-range ET patterns of metalloproteins.

General information
Publication status: Published
Organisations: Department of Chemistry, Department of Manufacturing Engineering, Department of Management Engineering, University of Liverpool
Contributors: Friis, E. P., Andersen, J. E. T., Madsen, L. L., Møller, P., Nichols, R., Ulstrup, J.
Pages: 2889-2897
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Electrochimica Acta
Volume: 43
Issue number: 19-20
ISSN (Print): 0013-4686
Original language: English
Source: orbit
Source ID: 170794
Research output: Contribution to journal › Journal article – Annual report year: 1998 › Research › peer-review

AN ELECTROPLATING METHOD OF FORMING PLATINGS OF NICKEL, COBALT, NICKEL ALLOYS OR COBALT ALLOYS
An electroplating method of forming platings of nickel, cobalt, nickel alloys or cobalt alloys with reduced stresses in an electrodepositing bath of the type: Watt's bath, chloride bath or a combination thereof, by employing pulse plating with periodic reverse pulse and a sulfonated naphthalene additive. This method makes it possible to deposit nickel, cobalt, nickel or cobalt platings without internal stresses.

General information
Publication status: Published
Organisations: Institute for Product Development, Department of Management Engineering, Chas. Hude A/S
Contributors: Tang, P. T., Dylmer, H., Møller, P.
Publication date: 1997

Publication information
Patent number: WO1997000980
Filing date: 09/01/1997
Original language: English

Bibliographical note
International application published under the World Intellectual Property Organization (WIPO)
Source: orbit
Source ID: 174345

Covalent immobilised cytochrome c imaged by in situ scanning tunneling microscopy
abstract

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Andersen, J. E., Olesen, K. G., Danilov, A. I., Foverskov, C. B., Møller, P., Ulstrup, J.
Pages: 43-57
Publication date: 1997
Peer-reviewed: Yes
Covalently Immobilised Cytochrome C Imaged by In Situ Scanning Tunnelling Microscopy

In situ scanning tunnelling microscopy (STM) imaging of cytochrome c (cyt c) on polycrystalline Pt surfaces and on Au(III) was achieved first by covalent immobilisation of 3-aminopropyltriethoxysilane (3-APTS) brought to react with oxide present on the Pt surfaces. Covalently bound 3-APTS forms a further link to glutaric dialdehyde which immobilises the protein molecules. Cyt c is immobilised on Au(III) by reaction with N-acetylcystein and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide. Imaging by in situ STM in a 20 mM phosphate buffer electrolyte with a Au/AuOx reference electrode could then be achieved. Protein was identified as hemispherical features on the surface with close to molecular resolution and with a quite different character compared both to the bare metal surfaces and to metal surfaces with only linker molecules attached. No subunits or side chains were visible, but the protein exhibited a grained surface appearance, possibly caused by mobile subunits or immobilising agent. (C) 1997 Elsevier Science S.A.
Electroplating of Porous Compacts

Abstract

Fabrication of an all-metal atomic force microscope probe

This paper presents a method for fabrication of an all-metal atomic force microscope probe (tip, cantilever and support) for optical read-out, using a combination of silicon micro-machining and electroforming. The paper describes the entire fabrication process for a nickel AFM-probe. In addition the first measurements with the new probe are presented.
Molybdate based passivation of zinc

In order to reduce corrosion rates, zinc plated parts are usually chromated. Recently chromates have caused increasingly environmental concern, for both allergic effects among workers touching chromated parts and toxic effects on fish, plants and bacteria. A molybdate based alternative has been developed to replace chromates in several passivation applications. Depending on the environment in which the passivated parts are to be exposed, the protection that this alternative treatment provides range from less efficient to more efficient as compared to chromate. These aspects as well as issues such as; cost, stability, layer composition and test results from several different corrosion tests will be discussed.

New approaches to atomic force microscope lithography on silicon

We have investigated new approaches to the formation of conducting nanowires on crystalline silicon surfaces using atomic force microscope (AFM) lithography. To increase processing speed and reduce wear of the AFM tip, large-scale structures are formed with a direct laser write setup, while the AFM is used to add the finer nanostructures. Both methods are based on selective oxidation of hydrogen-passivated silicon and subsequent etching to define conducting regions on the surface. This combined technique has previously been implemented on amorphous Si on oxide. To extend the technique to form crystalline silicon nanowires, we have used an arsenic implanted crystalline silicon layer on p-type Si, where the nanostructures are isolated from the substrate electrically due to p-n junction formation. Improvements in the reliability of the AFM lithography technique were achieved by using all-metal tips, which do not wear out as rapidly as metal-coated Si3N4 tips. (C) 1997 American Vacuum Society.
Proteins at Metallic Surfaces Investigated by in Situ Scanning Tunneling Microscopy

General information
Publication status: Published
Organisations: Department of Chemistry, University of Copenhagen
Contributors: Andersen, J. E. T., Friis, E. P., Thuesen, M. H., Karlsson, J., Ulstrup, J., Nielsen, M., Madsen, L. L., Møller, P.
Pages: 402-414
Publication date: 1997

Host publication information
Title of host publication: Electron and Ion Transfer in Condensed Media
Place of publication: Singapore
Publisher: World Scientific
Source: orbit
Source ID: 166253
Research output: Chapter in Book/Report/Conference proceeding – Annual report year: 1997
Research: peer-review

The Influence of Intermediate Particles on the Nucleation of Copper on Polycrystalline Platinum

General information
Publication status: Published
Organisations: Analytical Chemistry, Department of Chemistry, Materials and Surface Engineering, Department of Management Engineering, NanoChemistry, Russian Academy of Sciences
Contributors: Danilov, A. I., Andersen, J. E. T., Molodkina, E., Polukarov, Y., Møller, P., Ulstrup, J.
Pages: 733-741
Publication date: 1997
Peer-reviewed: Yes

Publication information
Journal: Electrochimica Acta
Volume: 43 nr. 7
ISSN (Print): 0013-4686
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7442/dk/
Source: orbit
Source ID: 187071
Research output: Contribution to journal – Journal article – Annual report year: 1997
Research: peer-review

A "Green" Passivation of Zinc containing surfaces as an alternative to chromate

General information
Publication status: Published
Organisations: Department of Manufacturing Engineering, Danfoss AS, NKT Group, Hempel AS
Publication date: 1996

Bibliographical note
Original language: English

MUP Project
Source: orbit
Source ID: 165891
Research: peer-review

Bulk Copper Electrodeposition on Gold Imaged by In Situ STM: Morphology and Influence of Tip Potential
Electrochemical measurements were carried out simultaneously with acquisition of in situ STM images of copper electrodeposition at low cathodic overpotentials and subsequent dissolution from the underlying polycrystalline gold
surfaces. The morphologies of the copper deposits were examined for correlation with features of the current-voltage diagram. Copper growth is by nucleation and formation of 3D islands. During the initial stages of bulk copper growth the potentials were fixed at selected values and a balance observed between formation of polycrystalline copper nuclei and of copper crystals. After the first cycle of copper deposition and dissolution the morphology of the polycrystalline gold surface had apparently changed into a recrystallized phase of a copper-gold alloy. At a given stage of the cycle the potential of the electrode was found to depend linearly on the tip potential. In a wide range of tip potentials the onset of copper deposition and end of dissolution showed a potential separation of 59 ± 5 mV indicating a single electron process.

Methods for Electrodepositing Composition-Modulated Alloys

Materials exhibiting unique mechanical, physical and chemical properties can be obtained by combining thin layers of different metals or alloys forming a multilayered structure. Two general techniques exist for electrodepositing composition-modulated alloy (CMA) materials; dual-bath and single-bath plating. For both techniques a number of variations exist. The most suitable technique and variation for the manufacture of a certain CMA material is highly dependent on the metals included in the given CMA system and on the dimensions of the multilayered structure. In this paper, the main principles of the two electrochemical techniques and their variants are discussed.
Perspectives for in situ Scanning Tunnel Microscopic Imaging of Metalloproteins at HOPG Surfaces

General information
Publication status: Published
Organisations: Analytical Chemistry, Department of Chemistry, Materials and Surface Engineering, Department of Mechanical Engineering, NanoChemistry, Technical University of Denmark
Contributors: Andersen, J. E. T., Jensen, M. H., Møller, P., Ulstrup, J.
Pages: 2005-2010
Publication date: 1996
Peer-reviewed: Yes

Perspectives for in situ Scanning Tunnel Microscopic Imaging of Proteins at HOPG surfaces

General information
Publication status: Published
Organisations: Department of Chemistry
Contributors: Andersen, J. E. T., Thuesen, M. H., Møller, P., Ulstrup, J.
Pages: 2005-2010
Publication date: 1996
Peer-reviewed: Yes

Pulse Plating

General information
Publication status: Published
Organisations: Department of Manufacturing Engineering
Contributors: Møller, P., Tang, P. T., Leisner, P.
Publication date: 1996

Host publication information
Title of host publication: Pulse Plating
Corrosion protective crack-free chromium electrodeposites

abstract

Corrosion protective crack-free chromium electrodeposites

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Møller, P.
Pages: [0 pp.]
Publication date: 1995
Peer-reviewed: Yes

Publication information
Journal: Electroplating & Surface Treatment
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7462/dk/
Source: orbit
Source ID: 187084
Research output: Contribution to journal › Journal article – Annual report year: 1995 › Research › peer-review

Cytochrome C Dynamics at Gold and Glassy Carbon Surfaces Monitored by in Situ Scanning Tunnel Microscopy

We have investigated the absorption of cytochrome c on gold and glassy carbon substrates by in situ scanning tunnel microscopy under potentiostatic control of both substrate and tip. Low ionic strength and potential ranges where no Faradaic current flows were used. Cyt c aggregates into flat composite structures of about 50 nm lateral extension at gold surfaces. The aggregates evolve in time, and structures resembling individual cyt c molecules can be distinguished in the space between the 50 nm structures. Cyt c aggregates also form at glassy carbon but have a different, unbroken character where cyt c both sticks well to the surface and exhibits notable mobility. The observations suggest that characteristic surface specific, internally mobile protein aggregates are formed at both surfaces and that in situ molecular resolution of the STM pictures may have been achieved.

General information
Publication status: Published
Organisations: Department of Chemistry, Department of Management Engineering
Contributors: Andersen, J. E. T., Møller, P., Pedersen, M. V., Ulstrup, J.
Pages: 193-205
Publication date: 1995
Peer-reviewed: Yes

Publication information
Journal: Surface Science
Volume: 325
Issue number: 1-2
ISSN (Print): 0039-6028
Original language: English
DOIs:
10.1016/0039-6028(94)00768-3
URLs:
http://www.ipl.dtu.dk/publikation/7460/dk/
Source: orbit
Source ID: 187082
Research output: Contribution to journal › Journal article – Annual report year: 1995 › Research › peer-review

Growth of a Copper-Gold Alloy Phase by Bulk Copper Electrodeposition on Gold Investigated by In Situ STM

Simultaneous in situ scanning tunneling microscopy measurements and recordings of voltammograms were used to study in real time the initial cycles of potentiostatic copper electrodeposition and subsequent dissolution on a clean gold polycrystalline electrode. The cycles were carried out by sweeping the potential in the double-layer charging region from 500 to -100 mV and back to 500 mV at a sweep rate of 1 mV/s in an acidified copper sulfate electrolyte (0.01M H2SO4, 0.01M CuSO4, and Millipore water). After completion of the first cycle the gold surface had recrystallized and nuclei of an alloy phase were formed. After completion of subsequent cycles the distribution of crystallite dimensions and the shape of
the crystallites changed and the growth was compared with features of concomitant voltammograms. Relations between charge densities and potentials were deduced from data of the voltammograms. A shift in peak potential for the anodic current transient from $E = 20$ mV to $E = -2$ mV was observed after completion of four subsequent cycles of copper electrodeposition/dissolution. The shift is suggested to be equal to the change in potential of the working electrode owing to the formation of the alloy phase.

**General information**
Publication status: Published
Organisations: Department of Chemistry, Department of Manufacturing Engineering
Contributors: Andersen, J. E. T., Møller, P.
Pages: 2225-2232
Publication date: 1995
Peer-reviewed: Yes

**Publication information**
Journal: Journal of The Electrochemical Society
Volume: 142
Issue number: 7
ISSN (Print): 0013-4651
Original language: English
Keywords: Corrosion
Electronic versions:
Per.pdf
URLs:
http://dx.doi.org/10.1149/1.2044279

**Bibliographical note**
Copyright The Electrochemical Society, Inc. [1995]. All rights reserved. Except as provided under U.S. copyright law, this work may not be reproduced, resold, distributed, or modified without the express permission of The Electrochemical Society (ECS).
Source: orbit
Source ID: 187083
Research output: Contribution to journal › Journal article – Annual report year: 1995 › Research › peer-review

**Nickel Coatings and Electroforming Using Pulse Reversal Plating**
Introducing pulse plating brings new life and possibilities to one of the oldest groups of electroplating processes. Nickel coatings and electroforming are used in a great variety of products, from oil valves to optical discs, and for many applications such as corrosion protection and micro-mechanics. A series of new results using pulse reversal plating in Watts based electrolytes will be discussed. Electro-forming completely without internal stress and with improved throwing power will be demonstrated, as well as a corrosion resistance of nickel coatings that could allow coating thicknesses, as well as allergy risks, to be significantly reduced.

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Tang, P. T., Dylmer, H., Møller, P.
Publication date: 1995

**Host publication information**
Title of host publication: SUR/FIN '95
Publisher: AESF
URLs:
http://www.ipl.dtu.dk/publikation/7751/dk/
Source: orbit
Source ID: 187272
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 1995 › Research › peer-review

**Analysis and Calibration of in situ scanning tunnelling microscopy Images with atomic Resolution Influenced by Surface Drift Phenomena**
The influence of surface drift velocities on in situ scanning tunnelling microscopy (STM) experiments with atomic resolution is analysed experimentally and mathematically. Constant drift velocities much smaller than the speed of scanning can in many in situ STM experiments with atomic resolution result in an apparent surface reconstruction. It is shown that a surface atomic structure can be distorted and observed as another atomic structure entirely owing to a constant drift velocity in the plane of the surface. The image can be resolved mathematically and the components of the drift velocity as
well as the vectors of the non-distorted surface lattice can be determined. The calibration of distances can thus be carried out also when the image is influenced by drift. Results with gold surfaces and graphite surfaces are analysed and discussed.

**General information**
- **Publication status:** Published
- **Organisations:** Department of Chemistry, Department of Management Engineering
- **Contributors:** Andersen, J. E. T., Møller, P.
- **Pages:** 213-220
- **Publication date:** 1994
- **Peer-reviewed:** Yes

**Publication information**
- **Journal:** Surface and Coatings Technology
- **Volume:** 67
- **Issue number:** 3
- **ISSN (Print):** 0257-8972
- **Original language:** English
- **DOIs:** 10.1016/0257-8972(94)90121-X
- **URLs:**
  - http://www.ipl.dtu.dk/publikation/7466/dk/
  - Source: orbit
  - Source ID: 187086
- **Research output:** Contribution to journal › Journal article – Annual report year: 1994 › Research › peer-review

**Bulk crystalline copper electrodeposition on polycrystalline gold surfaces observed by in-situ scanning tunneling microscopy**

Bulk copper electrodeposition onto technical gold surfaces in electrolytes of 0.05 M H2SO4 and 1 mM CuSO4 was investigated by in-situ scanning tunnelling microscopy at fixed overpotentials. At potentials between -60 and -30 mV the growth of bulk copper proceeds in cycles of nucleation, agglomeration and crystallization. Crystalline copper is seen as involving an intermediate stage in the progress of growth. The final stage in the growth involves an equilibrium of copper electrochemically dissolving and precipitating.

The drift velocity was measured for a gold surface subjected to flame annealing and subsequently installed in the cell compartment. It was found that the drift velocity decays with time in an exponential-like manner, and a 70 min waiting time before experiments with atomic resolution is recommended. Atomic resolution on Au(111) has been obtained, and an apparent surface reconstruction was observed. It is suggested that in reality no reconstruction took place, and that the observation was due to a distortion of the image caused by a constant drift velocity. A mathematical expression which relates the observed surface structure to the drift velocity is presented.

**General information**
- **Publication status:** Published
- **Organisations:** Department of Chemistry, Department of Management Engineering
- **Contributors:** Andersen, J. E. T., Bech-Nielsen, G., Møller, P.
- **Pages:** 87-95
- **Publication date:** 1994
- **Peer-reviewed:** Yes

**Publication information**
- **Journal:** Surface and Coatings Technology
- **Volume:** 70
- **Issue number:** 1
- **ISSN (Print):** 0257-8972
- **Original language:** English
- **DOIs:** 10.1016/0257-8972(94)90079-5
- **URLs:**
  - http://www.ipl.dtu.dk/publikation/7464/dk/
  - Source: orbit
  - Source ID: 187085
- **Research output:** Contribution to journal › Journal article – Annual report year: 1994 › Research › peer-review
Dual-bath Plating of Composition Modulated Alloys (CMA) based on a newly developed Computer Controlled Plating System

Composition Modulated Alloys (CMA) are attracting ever increasing interests, as new and fascinating applications are reported. Until recently, producing these multilayered coatings have been difficult, particularly for larger samples. This presentation will explain the design, use and purpose of a computer controlled plating system for producing large scale CMA-coatings. Employing a dual-bath technique, multilayered materials with more than 1000 alternating layers have been manufactured and investigated. The thickness of each layer ranges from 25 nm to several microns. The characterisation results, as obtained with SEM and applications for multilayered systems such as Cu/Ni and Cu/Co, as well as the possibilities and limitation of the plating system will be discussed.

Effects of Pretreatment on the Structure And Properties of Electroless Nickel Coatings

The pretreatment process can significantly affect the corrosion resistance of electroless nickel (EN) coatings. One of the most important reasons is that different pretreatment processes can give different surface morphologies of the substrate. The scanning electron microscope (SEM) and the scanning tunneling microscope (STM) have been used to investigate the structure and properties of EN coatings in the as-plated condition for various deposition times, in relation to different mechanical/chemical pretreatment processes. The morphology of the substrate surface is found to be a key factor in control of the porosity of EN coatings. It can significantly affect the formation of EN deposits, not only in the early stage but also in the morphology/structure during the continued growth of the deposit. Possible porosity is associated with the morphology of the substrate and the coalescence of the nodules in the coating.

Methods for Electrodepositing Composition Modulated Alloys

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Nielsen, C., Tang, P. T., Dörge, T., Møller, P.
Publication date: 1994
Peer-reviewed: Yes
Molybdate based Alternatives to Chromating as a Passivation Treatment for Zinc

Zinc-plated parts are typically passivated with chromate-based solutions to reduce corrosion. Chromates, however, are a cause of environmental concern, for their toxic effects on plants and wildlife, and allergic effects on workers who come in contact with them.

A molybdate-based alternative has been developed that can be used to replace chromates in a wide range of applications. The process has been tested in a project set up by the Danish Government in 1989, at the Centre of Advanced Electroplating (CAG) in Denmark. Procedures used for the alternative process are similar to those used in chromating. The corrosion protection provided by the process on zinc-plated parts is comparable to chromates. Depending on test conditions, especially pH value, the molybdate/phosphate process was found to be better than chromate at low pH values, equal to chromates in outdoor exposure tests and prohesion tests, but not as good in neutral tests, such as salt spray.

This edited version of a presentation from the joint AESF/EAST Session at SUR/FIN(R) '94-Indianapolis, discusses the effectiveness, cost, stability, chemistry, layer composition, and performance of this alternative process.

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Tang, P. T., Bech-Nielsen, G., Møller, P.
Pages: 20-23
Publication date: 1994
Peer-reviewed: Yes

Plating aspects of Joined Materials

abstract

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Møller, P.
Pages: [0 pp.]
Publication date: 1994
Peer-reviewed: Yes

Publication information
Journal: International Journal for the Joining of Materials
ISSN (Print): 0905-6866
Original language: English
URLs: http://www.ipl.dtu.dk/publikation/7470/dk/
Source: orbit
Source ID: 187088
Research output: Contribution to journal › Journal article – Annual report year: 1994 › Research › peer-review
Pulse Plating on Gold Surfaces Studied by In Situ Scanning Tunneling Microscopy
Deposition of bulk copper on thin film gold surfaces is carried out by computer-aided pulse plating. It is demonstrated that the morphology of the copper deposit can be studied by in situ scanning tunnelling microscopy both in potentiostatic experiments and in galvanostatic experiments. Optimized procedures for obtaining smooth deposits by pulse plating are explained in terms of a levelling effect. Possible non-faradaic processes observed in measurements with high frequency pulse plating are discussed.

General information
Publication status: Published
Organisations: Department of Chemistry, Department of Management Engineering
Contributors: Andersen, J. E. T., Bech-Nielsen, G., Møller, P.
Pages: 151-159
Publication date: 1994
Peer-reviewed: Yes

Publication information
Journal: Surface and Coatings Technology
Volume: 67
Issue number: 3
ISSN (Print): 0257-8972
Original language: English
DOIs:
10.1016/0257-8972(94)90114-7
URLs:
http://www.ipl.dtu.dk/publikation/7468/dk/
Source: orbit
Source ID: 187087
Research output: Contribution to journal › Journal article – Annual report year: 1994 › Research › peer-review

Pulse Plating used for Life-Cycle design
abstract

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Jensen, A., Møller, P.
Pages: 20-24
Publication date: 1994
Peer-reviewed: Yes

Publication information
Journal: Electroplating and Surface Treatment (Russian)
Volume: 3
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7480/dk/
Source: orbit
Source ID: 187093
Research output: Contribution to journal › Journal article – Annual report year: 1994 › Research › peer-review

Throwing Power and Ductility of Pulse Resersal Plated Copper for PCB's
abstract

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Møller, P., McNelly, A.
Pages: 148-154
Publication date: 1994
Peer-reviewed: Yes

Publication information
Current Efficiency and Crystallization Mechanism in Pulse Plating of Hard Chromium

**abstract**

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Bech-Nielsen, G., Møller, P.
Pages: 1232-1236
Publication date: 1993
Peer-reviewed: Yes

**Publication information**
Journal: Journal of Applied Electrochemistry
Volume: 23
ISSN (Print): 0021-891X
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7489/dk/
Source: orbit
Source ID: 187100
Research output: Contribution to journal › Journal article – Annual report year: 1993 › Research › peer-review

Effects of the Substrate Surface Morfology on the Porosity of Electroless Nickel Coatings

**abstract**

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Deng, H., Møller, P.
Pages: 142-147
Publication date: 1993
Peer-reviewed: Yes

**Publication information**
Journal: Transactions of the Institute of Metal Finishing
Volume: 71
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7481/dk/
Source: orbit
Source ID: 187094
Research output: Contribution to journal › Journal article – Annual report year: 1993 › Research › peer-review

Improvements of Nickel Deposit Characteristics by Pulse Plating

Investigation of the properties of electroplated nickel, using both pulse plating and conventional direct current (DC), has lead to several interesting improvements of deposit characteristics. Investigated properties include; internal stress, tensile strength, yield stress, elongation, hardness, throwing power, current efficiency and corrosion resistance (porosity). Experiments have been made with Watts nickel baths, sulphamate baths and a modified Watts bath called W3.

**General information**
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Tang, P. T., Leisner, P., Møller, P.
Charakteristische Aspekte bei Pulse Plating

abstract

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Leisner, P., Møller, P.
Pages: [10 pp.]
Publication date: 1992
Peer-reviewed: Yes

Publication information
Journal: Galvanotechnik
Volume: 83
Original language: English
URLs:
http://www.ipl.dtu.dk/publikation/7491/dk/
Source: orbit
Source ID: 187102
Research output: Contribution to journal › Journal article – Annual report year: 1992 › Research › peer-review

Overfladebehandling af Aluminium og Magnesium

General information
Publication status: Published
Organisations: Department of Management Engineering
Contributors: Møller, P.
Publication date: 1992

Host publication information
Title of host publication: Dansk Metallurgisk Selskabs Vintermøde
Source: orbit
Source ID: 187110
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 1992 › Research

Projects:

Surface engineering of aluminium alloys for prosthetics
Andersen, A. G., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Hansen, J., Supervisor
Jørgensen, R. S., Supervisor
Nielsen, L. P., Supervisor
Olafsson, S., Supervisor
Industrial PhD
01/01/2018 → 31/12/2020
Award relations: Surface engineering of aluminium alloys for prosthetics
Project: PhD
Surface engineering of Fe-C coatings
Nielsen, J. O., PhD Student, Department of Mechanical Engineering
Pantleon, K., Main Supervisor
Møller, P., Supervisor
Samfinansieret - Andet
01/01/2017 → 31/12/2019
Award relations: Surface engineering of Fe-C coatings
Project: PhD

Development of electrochemically deposited surfaces based on copper and silver with bacterial effect
Ciacotich, N., PhD Student, Department of Systems Biology
Gram, L., Main Supervisor
Bjarnsholt, T., Supervisor
Møller, P., Supervisor
Tang, P. T., Examiner
Allesen-Holm, M., Examiner
Solioz, M., Examiner
Industrial PhD
01/07/2016 → 30/06/2019
Award relations: Development of electrochemically deposited surfaces based on copper and silver with bacterial effect
Project: PhD

Metalafgivelse ved korrosion og slid i fødevareindustri
Jellesen, M. S., PhD Student, Department of Management Engineering
Møller, P., Main Supervisor
Hilbert, L. R., Supervisor
Leygraf, C., Examiner
Ambat, R., Examiner
Nielsen, L. P., Examiner
Offentlig finansiering
01/05/2004 → 21/12/2007
Award relations: Metalafgivelse ved korrosion og slid i fødevareindustri
Project: PhD

Styrkeøgende mekanismer i elektrokemisk udfærdede belægninger
Rasmussen, A. A., PhD Student, Department of Management Engineering
Somers, M. A. J., Main Supervisor
Møller, P., Supervisor
Petrushina, I., Examiner
Holmbom, L. G., Examiner
Landolt, D., Examiner
DTU-lønnet stipendie
01/02/2000 → 24/08/2004
Award relations: Styrkeøgende mekanismer i elektrokemisk udfærdede belægninger
Project: PhD

Electrocatalytic Materials
Villadsen, S. N. B., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor, Department of Mechanical Engineering
Nielsen, L. P., Supervisor
Hansen, H. N., Main Supervisor
Fosbøl, P. L., Supervisor
Møller, P., Supervisor
Samfinansieret - Andet
15/09/2016 → 14/09/2019
Award relations: Electrocatalytic Materials
Project: PhD

Improving endurance of wind-turbine coatings for use in offshore environments
Johansen, N. F., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Bech, J. I., Supervisor
Samfinansieret - Andet
01/06/2016 → 31/08/2019
Award relations: Improving endurance of wind-turbine coatings for use in offshore environments
Project: PhD

Development of new decorative nickel and chromium like coating systems with better chemical and physical properties
Reveko, V., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Tang, P. T., Examiner
Andriyko, Y., Supervisor
Nielsen, L. P., Examiner
Leisner, P., Examiner
Ansat eksternt
01/02/2015 → 31/07/2018
Award relations: Development of new decorative nickel and chromium like coating systems with better chemical and physical properties
Project: PhD

AC-Corrosion of Cathodically Protected Pipelines
Olesen, A. J., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Nielsen, L. V., Supervisor
Tang, P. T., Examiner
Büchler, M., Examiner
Lindemuth, D., Examiner
Industrial PhD
01/12/2014 → 14/02/2019
Award relations: AC-Corrosion of Cathodically Protected Pipelines
Project: PhD

Quartz Coated Metals for Hygienic applications in Food, Pharma and Medical Industry
Lampert, F., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Boye Rasmussen, J., Supervisor
Minzari, D., Examiner
Nielsen, L. P., Examiner
Taylor, S. R., Examiner
Forskningsrådsfinansiering
01/10/2014 → 11/01/2018
Award relations: Quartz Coated Metals for Hygienic applications in Food, Pharma and Medical Industry
Project: PhD

Electroplating of Protective coatings on interconnects used for solid oxide fuel cell stacks
Harthøj, A., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Boye Rasmussen, J., Supervisor
Tang, P. T., Examiner
Froitzheim, J., Examiner
Leisner, P., Examiner
ErhvervsPhD-ordningen VTU
01/01/2011 → 03/12/2014
Award relations: Electroplating of Protective coatings on interconnects used for solid oxide fuel cell stacks
Project: PhD

Self cleaning paint: Introduction of Photocatalytic Particles into a Paint System
Gunnarsson, S. G., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Ottosen, L. M., Supervisor
Erik Weinell, C., Examiner
Larsson, A., Examiner
Paatsch, W., Examiner
Poulsen, S., Supervisor
ErhvervsPhD-ordningen VTU
01/04/2008 → 02/05/2012
Award relations: Self cleaning paint: Introduction of Photocatalytic Particles into a Paint System
Project: PhD

Optimering af formalingsteknologi i cementindustrien
Jensen, L. R. D., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Brockhoff, P. B., Supervisor
Friis, H., Supervisor
Jespersen, M., Supervisor
Nielsen, L. P., Examiner
Johnsen, R., Examiner
Sandvik, K. L., Examiner
ErhvervsPhD-ordningen VTU
01/10/2006 → 20/01/2010
Award relations: Optimering af formalingsteknologi i cementindustrien
Project: PhD

Advanced Anodising Technology (Avanceret Anodiserings Teknologi)
Tabrizian-Ghalehno, N., PhD Student, Department of Mechanical Engineering
Hansen, H. N., Main Supervisor
Ambat, R., Supervisor
Kongstad, I., Supervisor
Møller, P., Supervisor
Toftegård, J., Supervisor
De Chiffre, L., Examiner
Leisner, P., Examiner
Nielsen, L. P., Examiner
ErhvervsPhD-ordningen VTU
01/09/2006 → 06/01/2010
Award relations: Advanced Anodising Technology (Avanceret Anodiserings Teknologi)
Project: PhD

Monitoring of Reinforcement Corrosion
Nygaard, P. V., PhD Student, Department of Civil Engineering
Geiker, M. R., Main Supervisor
Møller, P., Supervisor
Goltermann, P., Examiner
Edvardsen, C., Examiner
Hansson, C. M., Examiner
Klinghoffer, O., Supervisor
ErhvervsPhD-ordningen VTU
01/08/2004 → 21/10/2009
Award relations: Monitoring of Reinforcement Corrosion
Project: PhD

Manufacture of Aluminium Displays Based on Micro Technology
Prichystal, J., PhD Student, Department of Management Engineering
Hansen, H. N., Main Supervisor
Møller, P., Supervisor
Bruus, H., Examiner
Dausinger, F., Examiner
Leisner, P., Examiner
Bladt, H. H., Supervisor
ErhvervsPhD-ordningen VTU
01/01/2004 → 31/08/2007
Award relations: Manufacture of Aluminium Displays Based on Micro Technology
Project: PhD
Antifouling surfaces
Chiang, W., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Hilbert, L. R., Supervisor
Tolker-Nielsen, T., Supervisor
Ambat, R., Examiner
Bjarnsholt, T., Examiner
Leisner, P., Examiner
Privatist
01/08/2005 → 06/01/2010
Award relations: Antifouling surfaces
Project: PhD

Elektrolytisk zink: Proces, mikrostruktur og korrosion
Fontenay, F. L. S. D., PhD Student, Department of Management Engineering
Møller, P., Main Supervisor
Paatsch, W., Examiner
Leisner, P., Examiner
Jacobsen, T., Examiner
Anden sektorministeriel finansiering - SU
01/01/1999 → 09/07/2002
Award relations: Elektrolytisk zink: Proces, mikrostruktur og korrosion
Project: PhD

Development of low cost electrocatalysts for oxygen evolution in advanced alkaline electrolyzers
Egelund, S. D., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Jensen, J. A. D., Supervisor
Nielsen, C. V., Supervisor
Tang, P. T., Examiner
Leisner, P., Examiner
Johnsen, R., Examiner
Ansat eksternt
01/04/2012 → 24/09/2015
Award relations: Development of low cost electrocatalysts for oxygen evolution in advanced alkaline electrolyzers
Project: PhD

High efficiency, low-cost cathode electrodes durable in advanced alkaline electrolyzers
Caspersen, M., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Jensen, J. A. D., Supervisor
Nielsen, C. V., Supervisor
Tang, P. T., Examiner
Leisner, P., Examiner
Johnsen, R., Examiner
Ansat eksternt
01/04/2012 → 24/09/2015
Award relations: High efficiency, low-cost cathode electrodes durable in advanced alkaline electrolyzers
Project: PhD

2nd Generation Alkaline Electrolysis for Hydrogen Production
Kjartansdóttir, C. K., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Tang, P. T., Examiner
Jensen, J. A. D., Examiner
Leisner, P., Examiner
Programbevilling
01/11/2009 → 21/02/2014
Award relations: 2nd Generation Alkaline Electrolysis for Hydrogen Production
Project: PhD
Developing Strategies for Corrosion Protection of Electronic Devices
Rathinavelu, U., PhD Student, Department of Mechanical Engineering
Ambat, R., Main Supervisor
Møller, P., Supervisor
Nielsen, L. P., Examiner
Johnsen, R., Examiner
Leisner, P., Examiner
Forskningsrådssifansiering
01/05/2008 → 21/12/2011
Award relations: Developing Strategies for Corrosion Protection of Electronic Devices
Project: PhD

Investigation of Electronic Corrosion Mechanisms
Minzari, D., PhD Student, Department of Mechanical Engineering
Ambat, R., Main Supervisor
Møller, P., Supervisor
Nielsen, L. P., Examiner
Azarian, M., Examiner
Møl, A., Examiner
Forskningsrådssifansiering
01/04/2007 → 29/09/2010
Award relations: investigation of Electronic Corrosion Mechanisms
Project: PhD

Surface Embedded Metal Oxide Sensors (SEMOS)
Ali, S. T., PhD Student, Department of Mechanical Engineering
Møller, P., Main Supervisor
Nielsen, L. P., Supervisor
Ambat, R., Examiner
Hilbert, L. R., Examiner
Leisner, P., Examiner
Forskningsrådssifansiering
01/08/2007 → 06/04/2011
Award relations: Surface Embedded Metal Oxide Sensors (SEMOS)
Project: PhD

Smart Surface Materials in Industrial Food Frying
Ashokkumar, S., PhD Student, National Food Institute
Adler-Nissen, J., Main Supervisor
Hinke, J., Supervisor
Møller, P., Supervisor
Risum, J., Examiner
Fontenay, F. L. S. D., Examiner
Paatsch, W., Examiner
ErhvervsPhD-ordnningen VTU
15/08/2007 → 20/04/2011
Award relations: Smart Surface Materials in Industrial Food Frying
Project: PhD

High temperature solder for MEMS packaging
Bergmann, R., PhD Student, Department of Mechanical Engineering
Hansen, H. N., Main Supervisor
Johansen, L. S., Supervisor
Møller, P., Supervisor
Tang, P. T., Supervisor
Hansen, O., Examiner
Heschel, M., Examiner
Leisner, P., Examiner
ErhvervsPhD-ordnningen VTU
01/02/2006 → 02/09/2009
Award relations: High temperature solder for MEMS packaging
Project: PhD
Management of Reinforcement Corrosion
Küter, A., PhD Student, Department of Civil Engineering
Geiker, M. R., Main Supervisor
Møller, P., Supervisor
Ottosen, L. M., Examiner
Hansson, C. M., Examiner
Leisner, P., Examiner
DTU-lønnet stipendie
01/10/2003 → 07/05/2009
Award relations: Management of Reinforcement Corrosion
Project: PhD

Metal Release by Corrosion and Wear in the Food Industry
The objectives of this project are to identify the sources of metal contamination from stainless steel equipment in food industry, analyse the impact of the contamination and finally to suggest solutions for the problem. Metal release can cause a health risk for consumers with nickel allergy and the acquisition of data on metal content in not only raw products but also in manufactured food and ready-to-eat dishes will be an improvement of the present status.

The role of the National Food Institute is to analyse trace elements in processed raw materials and foodstuffs sampled at various sites along the process line in the food industry. The trace element content is determined by Inductively Coupled Plasma Mass Spectrometry (ICPMS) equipped with a collision/reaction cell for interference reduction/removal. The obtained data on food products will be analysed and the health risk evaluated by comparison with the estimated daily intake.

By materials selection and development of more wear and corrosion resistant surfaces the general food quality can be improved, metal release reduced and longer lifetime of process equipment obtained – all leading to better products. So by technological solutions safe and high quality food production can be made possible.

Project financing:
The project is funded by The Directorate for Food, Fisheries and Agri Business, DFFE and has a total budget of 6.1 mill kroner. The National Food Institute has a budget of 0.9 mill kr.

Sloth, J. J., Project Manager, National Food Institute, Division of Food Chemistry
Larsen, E. H., Project Participant, National Food Institute, Division of Food Chemistry
Møller, P., Project Participant, Department of Mechanical Engineering, Materials and Surface Engineering
Poulsen, L. K., Project Participant
01/01/2003 → 01/01/2007
Collaborators: Righospitalet
Project: Research

Center for hygienic design
The project Hygienic Design is a co-operation between the Technical University, research institutes and partners from the food processing and biochemical industry. Biofilm formation is a major concern in food processing industry. It is aimed to improve surface material hygienic lifetime by selecting surface materials in combination with cleaning chemicals and cleaning procedures. Department of Manufacturing Engineering and Management is involved in development of materials with low bioadhesion (resistance towards biofilm formation), designed on the basis of effect of surface structure, surface chemistry, and cleaning properties. The work also includes development of quantitative techniques for examination of bioadhesion as well as corrosion. Studies have been made of the effect of surface finish of stainless steel 316 on adhesion of bacteria in stagnant media and under flow as well as field tests.

Hilbert, L. R., Project Manager, Department of Manufacturing Engineering
Albæk, M., Project Participant, Department of Manufacturing Engineering
Møller, P., Project Participant, Department of Manufacturing Engineering
01/01/1998 → 31/12/2002
Project: Research

Strengthening mechanisms in electrochemically deposited layers
Investigation of the possibilities for strengthening in small components, where some of the classical mechanisms for strengthening of materials no longer are valid.

Somers, M. A. J., Project Manager, Department of Manufacturing Engineering
Møller, P., Project Participant, Department of Manufacturing Engineering
01/02/2000 → 31/01/2003
Project: Research

Pulse Anodising of Extruded and Cast Aluminium Alloys
Ph.D. project involving Skanaluminium and Danfoss A/S
Add-on Metallic Microstructures for CMOS
This project aims at further development of the microlithography and electroplating process to allow released multilayer metallic structures for sensor purposes to be fabricated. In the process development compatibility with CMOS processing is emphasized, as compatibility will allow for monolithic smart sensors with integrated signal processing. We have realized very well defined released multilayer structures in pure Nickel and are trying to realize the same high quality structures in Nickel Iron alloys, that allow fabrication of high performance magnetic transducers. However, we have solved the problems with the stress control in the deposited Nickel Iron alloys. This work is also related to the SOI-CMOS project at MIC. To further the development in the project, Leif Steen Johansen worked for 4 months at Frauenhofer Institut fur Silizium Technologie, Berlin.

Thick Photoresist and Electroplating
As a part of a MUPPII programme at IPT we have a cooperative effort on development of a microfabrication technology for metallic microstructures using a combination of microlithography and electroplating. In the project, techniques for structuring very thick photoresist moulds, which are subsequently filled with low stress electroplated metal has been developed. The process development work is still continuing e.g. in order to be able to use new materials in the process. During the project several novel micromechanical devices have been fabricated, among these the first all-metal microfabricated AFM-probe (AFM: Atomic Force Microscope). The probe have a number of interesting potential applications. First of all it can be applied for a combined AFM and STM (STM: Scanning Tunnelling Microscope) measurement. Secondly it can be used for nanolithography, where it is expected to be more rugged than the usual metal coated nitride cantilevers. The probe is being commercialized by DME A/S. The work on the all metal cantilevers is accepted for presentation at Transducers 97. Whereas the technology development was presented at 83th AESF Annual Technical Conference SUR/FIN >96. (P.T.Tang, M.E. Benzon J.P.Rasmussen, and F.S. Fontenay: Important parameters and applications for Nickel Electroforming@ in Proc. Of 83th AESF Annual Technical Conference SUR/FIN >96(AESF, Cleveland Ohio, 1996))

Programme for Metallic Micro Parts
Development and fabrication of processes and components on a micro scale by a combination of micromachining and electrochemical deposition (ECD).

Neural process optimization of pulse plating in the electronic industry
The purpose of the project is to optimize the pulse plating process using mathematical models. The traditional electronic industry uses a chemical bath with additives to make the through-hole plating on printed circuit boards.
The pulse plating process can make the through plating without the additives and even improve the quality of the copper. So there is both solution to a environmental problem and a quality problem.

Based on the measurements from plated printed circuit boards the mathematical model is used find the optimal pulse parameters. In this project there is used artificial neural nets to solve the problem. With the final model it should be possible to "feed" the neural net with a CAD-design. Based on the design and the "knowledge" of the neural net it will be possible to compute the optimal pulse parameters.

Larsen, J., Project Manager, Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Helbo, C., Project Participant, Department of Manufacturing Engineering
Møller, P., Project Participant, Department of Manufacturing Engineering

Ukendt: DKK250,000.00
01/02/1998 → …

Collaborators: Elcon Pcb Technology A/S, CHEMBO Productions Ltd A/S, AXA Axel Åkerman A/S
Award relations: Neural process optimization of pulse plating in the electronic industry
Project: Research

Metal release by corrosion and wear in food industry
The objectives of this project are to identify the sources of metal contamination from stainless steel equipment in food industry, analyse the impact of the contamination and finally to suggest solutions for the problem. Metal release can cause a health risk for consumers with nickel allergy and the acquisition of data on metal content in not only raw products but also in manufactured food and ready-to-eat dishes will be an improvement of the present status. The obtained data on food products will be analysed and compared with challenge doses and estimated daily intake. By materials selection and development of more wear and corrosion resistant surfaces the general food quality can be improved, metal release reduced and longer lifetime of process equipment obtained – all leading to better products. So by technological solutions safe and high quality food production can be made possible.

Møller, P., Project Manager, Department of Management Engineering
Hilbert, L. R., Project Manager, Department of Management Engineering
Rasmussen, A. A., Project Participant, Department of Management Engineering
Albæk, M., Project Participant, Department of Management Engineering
Dam, H. C., Project Participant, Unknown Organization
Jellesen, M. S., Project Participant, Unknown Organization
Person, U., Project Manager, Danish Veterinary and Food Administration
Person, U., Project Manager, Copenhagen University Hospital

Forskningsprojekter - Fødevareministeriet: DKK4,661,000.00
01/08/2003 → 31/12/2007

Collaborators: Copenhagen University Hospital, Unknown Organization, Danish Veterinary and Food Administration
Award relations: Metal release by corrosion and wear in food industry
Project: Research

Center for hygienic design
The project Hygienic Design is a co-operation between the Technical University, research institutes and partners from the food processing and biochemical industry. Biofilm formation is a major concern in food processing industry. It is aimed to improve surface material hygienic lifetime by selecting surface materials in combination with cleaning chemicals and cleaning procedures. Department of Manufacturing Engineering and Management is involved in development of materials with low bioadhesion (resistance towards biofilm formation), designed on the basis of effect of surface structure, surface chemistry, and cleaning properties. The work also includes development of quantitative techniques for examination of bioadhesion as well as corrosion. Studies have been made of the effect of surface finish of stainless steel 316 on adhesion of bacteria in stagnant media and under flow as well as field tests.

Hilbert, L. R., Project Manager, Department of Management Engineering
Møller, P., Contact Person, Department of Management Engineering
Albæk, M., Project Participant, Department of Management Engineering

Forskningsprojekter - Erhvervsministeriet: DKK2,016,000.00
01/05/1998 → 01/12/2002

Award relations: Center for hygienic design
Project: Research