Nanoscale surface topographies for structural colors

The thesis describes and demonstrates the possibilities for utilization of structural colors in mass fabricated plastic products as replacement for or in combination with pigments and inks. The motivation is the possible advantages related to re-cycling and re-use of plastic by limiting the number of materials in a given plastic part. Also, the reduction of process steps and materials leads to a reduction of the fabrication costs. In the thesis only surfaces, which may be fabricated using replication based methods, such as injection molding, are considered.

Nanostructures with sizes comparable to the wavelength of visible light are theoretically and experimentally investigated. These structures interact with light such that the appearance of a surface is modified.

It is shown how sufficiently small tapered nanostructures lead to an anti-reflective effect were the reflection of light at the air-polymer interface is suppressed. This improves the ability to see through a clear plastic in the presence of specular reflection. The tapered nanostructures are also utilized to enhance the chroma of pigmented polymers.

Larger tapered structures fabricated in a similar manor are shown to work as color filters. Through an experimental study is the color of the transmitted light linked directly to the random topography of the surface by use of diffraction theory. The color effects from periodic structures and how these might be employed to create bright colors are investigated. This is done both for opaque samples and transparent foils. In the latter case the specific sample geometry may be utilized to create a zero order reflectance, which is significantly higher than what may be achieved by a single interface.

When the design limitations are relaxed and a small amount of post processing of the nanostructured plastic is done, more possibilities arise. A surface utilizing the concept of localized surface plasmon resonances (LSPR) is produced, when an ultra-thin layer of aluminum is deposited on a suitable nanostructured plastic surface.

The choice of aluminum as active plasmonic material is based on cost and abundance aspects, but also advantages within robustness and optical properties compared to other metals commonly used for plasmonic applications.

Hybridization theory is used to describe the behavior of the surface and a parameter space is identified where it by proper choice of vertical geometrical parameters is possible to create a plurality of bright colors by varying the lateral parameters only.

It is shown how diffraction effects and excitation of surface plasmon polaritons constitute the main limitations on the angular sensitivity of the surface.

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