Advances in the chemical vapor deposition (CVD) of Tantalum

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CHEMICAL VAPOUR DEPOSITION (CVD) OF TANTALUM

- In Long narrow channels

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Why Tantalum?

Percentage Weight loss in 10 wt % HCl, room temperature, α-alumina abrasives and 1000 rpm for 168 hours.

Tantalum Coated Plate Heat Exchanger
**SYSTEM DESCRIPTION**

\[ Ta_{(s)} + 2.5 Cl_2(g) \rightarrow TaCl_5 \]

\[ TaCl_5 + \frac{5}{2} H_2 \rightarrow Ta + 5 HCl \]
Modeling

Long narrow Channel: **Tubes**

Fluid Flow: **Navier Stokes**

Diffusion: **Fick’s Law**

Chemical Reaction: **Arrhenius**

Adsorption: **Langmuir**
Results:

Experiment 800°C, 25 mbar

Tantalum Thickness [µm/h] vs. Position in tube [m]
Experiment 850°C, 25 mbar

Tantalum Deposition Rate [µm/h]

Position in tube [m]

Try 1

Try 2

Try 3
Experiment 900°C, 25 mbar

Tantalum Deposition Rate [µm/h]

Position in tube [m]

- Try 1
- Try 3
- Try 4
Experiment 950°C, 25 mbar

Tantalum Deposition rate [µm/h] vs. Position in tube [m]

- **Try 1**
- **Try 2**
All Temperatures, 25 mbar

Tantalum Deposition rate [µm/h]

Position in tube [m]

- 800 C
- 850 C
- 950 C
- 900 C × 4
All Pressures, 800 °C

Tantalum Layer Deposition Rate [µm/h]

Position in the Tube [m]

- 25 mbar -- 50g Cl₂/h
- 100 mbar -- 50g Cl₂/h
- 300 mbar -- 30g Cl₂/h
- 1 atm -- 30g Cl₂/h
Model Fitting
Model

Fluid Flow: Navier Stokes

Diffusion: Fick’s Law

Adsorption: Langmuir

Chemical Reaction: Arrhenius

Geometry: 2D Axial Symmetry and 3D

Software: COMSOL MultiPhysics®
Mechanism

\[ TaCl_5(g) + \frac{1}{2}H_2 \rightarrow TaCl_4(g) + \frac{1}{2}H_2 \]

\[ TaCl_4(g) + HCl(g) \rightarrow TaCl_3(g) + HCl(g) \]

\( \text{Adsorption} \quad + 2H_2(g) \quad \text{Adsorption} \quad + \frac{3}{2}H_2(g) \)

\[ Ta(s) + 4HCl(g) \quad Ta(s) + 3HCl(g) \]

\( \text{Gas Phase Reaction} \quad \rightarrow \quad \text{Surface Reaction} \)
Model Fitting – 800 °C

Tantalum Deposition Rate um/h

Position in tube [m]
Model Fitting – 850 °C

Tantalum Deposition Rate μm/h

Position in tube [m]
Model Fitting – 900 °C

Tantalum Deposition Rate um/h

Position in tube [m]
Model Fitting – 950 °C

Tantalum Deposition Rate um/h vs. Position in tube [m]
Application
CB30 – Channel
CB30 – Channel (X-Y Plane)
CB30 – Streamline: Velocity field Visualization
CB30 – Streamline: Velocity field Visualization
CB30 – 1st Run: Tantalum Layer Thickness (i.e. Only treated from the right end)
CB30 – 1st Run: Tantalum Layer Thickness (i.e. Only treated from the left end)
CB30 – 2nd Run: Tantalum Layer Thickness (i.e. Treated from the both ends)
CB30 – 2\textsuperscript{nd} Run: Tantalum Layer Thickness (i.e. Treated from the both ends)
Thank you for your attention.