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

\[
Ta_{(s)} + 2.5Cl_2_{(g)} \rightarrow TaCl_5
\]

\[
TaCl_5 + \frac{5}{2}H_2 \rightarrow Ta + 5HCl
\]
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] for Try 1 and Try 2.
Experiment 850°C, 25 mbar

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

Try 1
Try 2
Try 3
Experiment 900°C, 25 mbar

![Graph showing Tantalum Deposition Rate vs Position in tube](#)
Experiment 950ºC, 25 mbar

![Graph showing Tantalum Deposition rate vs Position in tube [m]. The graph includes two sets of data points: Try 1 (diamonds) and Try 2 (crosses). The deposition rate decreases as the position in the tube increases.](image)
All Temperatures, 25 mbar

Tantalum Deposition rate [µm/h]

Position in tube [m]

- 800 C
- 850 C
- 950 C
- 900 C X 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

![Diagram showing atomic percent hydrogen vs. pressure at different temperatures.](image-url)
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

\[ \text{TaCl}_5(g) + \frac{1}{2}H_2 \rightarrow \text{TaCl}_4(g) + \frac{1}{2}H_2 \rightarrow \text{TaCl}_3(g) \]

Adsorption

\[ \text{Ta}_(s) + 4\text{HCl}(g) \]

Gas Phase Reaction

\[ \text{Ta}_(s) + 3\text{HCl}(g) \]

Surface Reaction

\[ +\text{HCl}(g) \]

Adsorption

\[ +2H_2(g) \]

\[ +\frac{3}{2}H_2(g) \]
Tantalum Deposition Rate um/h vs Position in Tube [m]

Model Fitting – 800 °C
Model Fitting – 850 °C

Tantalum Deposition Rate μm/h

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

Tantalum Deposition Rate um/h vs Position in tube [m]
Model Fitting – 950 °C

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

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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 – 2\textsuperscript{nd} Run: Tantalum Layer Thickness (i.e. Treated from the both ends)
CB30 – 2nd Run: Tantalum Layer Thickness (i.e. Treated from the both ends)
Thank you for your attention.