Modeling diffusion in ceramic coatings

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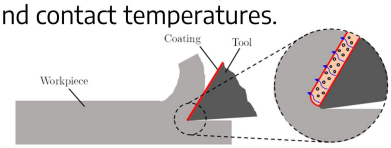
Nanotechnologies

Motivation: Difficult-to-machine materials

• New wear-resistant and lubricating coatings are needed to machine difficult-to-machine alloys (*e.g.,* Ti alloys used in aerospace and automotive industries) under dry conditions.
• Through the collaboration between UT-Austin and the University of Coimbra, a self-lubricating TiSiN-Ag coating was evaluated as candidate coating for machining tools.
• TiSiN-Ag coating combines high hardness with the ability of releasing of a lubricious Ag phase able to reduce cutting forces and contact temperatures.

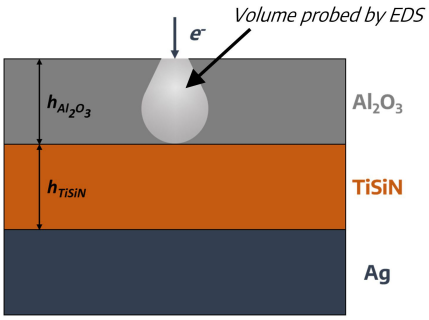
Research question
What is the rate of Ag out-diffusion from TiSiN-Ag?



Methodology: Accumulation of mass

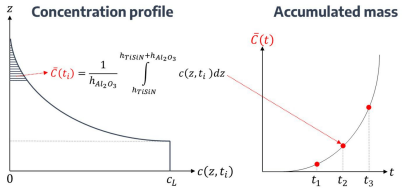
• To quantify the diffusion of Ag through TiSiN, an oxidation barrier coating, Al_2O_3, is first deposited on TiSiN since it provides two advantages:

I) Avoid the oxidation of TiSiN upon long annealing times in oxidizing environments.
II) Quantify the mass of Ag accumulated in Al_2O_3 through energy-dispersive X-ray spectroscopy (EDS) measurements.



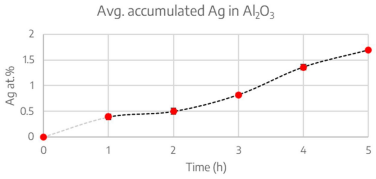
Diffusion modeling

• The accumulated mass of Ag in Al_2O_3 can be modeled by solving an initial boundary value problem (IBVP).



Experiments

• Ag/TiSiN/Al_2O_3 samples were annealed at 900°C for 5 hours and the average accumulated Ag in Al_2O_3 was quantified by EDS:



Future work: Parametric fitting

• The diffusivities of Ag into TiSiN and Al_2O_3 can be estimated by means of a parametric fitting of the experimental curve of Ag accumulated in Al_2O_3.

• The use of oxidation barrier coatings is particularly suitable for studying the diffusion of metals in oxidizable ceramics (e.g., carbides and nitrides).

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