INTERACTION VOLUME EFFECTS OF ULTRASONICALLY CONSOLIDATED CU/AL CONCENTRATION PROFILES

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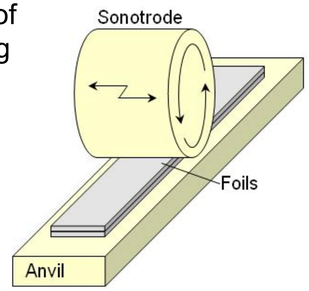
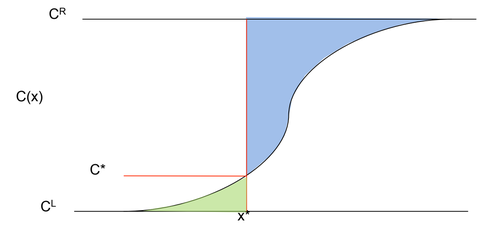
WHAT IS ULTRASONIC CONCOLIDATION?

- Ultrasonic Consolidation (UC) is a solid-state processing technique that can be used to weld metal foils together.
- Using a foil-fiber-foil method or prepreg tapes, metal matrix composite (MMC) structures can be fabricated through a layered build-up process.
- Metal foils are placed on top of a stationary anvil and a rotating horn travels the length of the foils.
- Three machine variables:
  - Applied normal force or load
  - Oscillation amplitude
  - Welding speed



MOTIVATION

- In order to optimize the bond strength, it is important to identify and quantify the primary bonding mechanisms.
- There has been evidence supporting diffusion as a bonding mechanism for UC, but it has not been quantified.
  - Increased dislocation densities and subgrain formation at the interface provide fast paths for diffusion.
- It is important to obtain accurate and consistent concentration profiles to minimize the variation in the interdiffusion coefficient calculations.

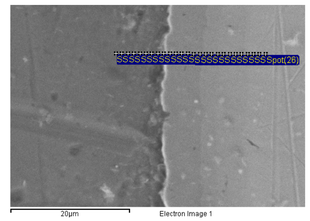


$$\tilde{D} = \frac{1}{2t\left.\frac{\partial C}{\partial X}\right|_{C^*}}\left[(1-\varphi)\int_{-\infty}^{x^*}(C(x)-C^L)dx + \varphi\int_{x^*}^{\infty}(C^R-C(x))dx\right]$$

$$\text{where}\quad \varphi = \frac{C^*-C^L}{C^R-C^L}$$

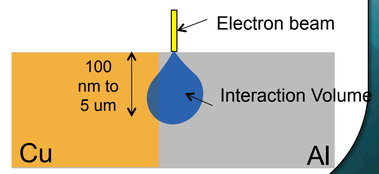
EXPERIMENTAL PROCEDURE

- X-ray energy dispersive spectroscopy (XEDS) in the scanning electron microscope can be used to measure concentrations across the interface.



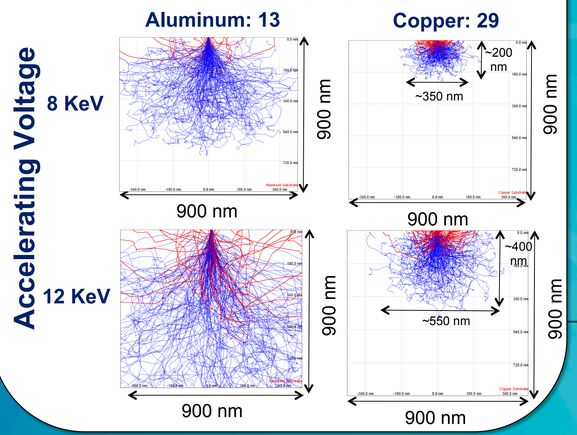
INTERACTION VOLUME INTERFERENCE

- The interaction volume is the space within the specimen through which reactions occur when struck by energetic electrons.
- Size and shape depend on:
  - Atomic number
  - Accelerating voltage



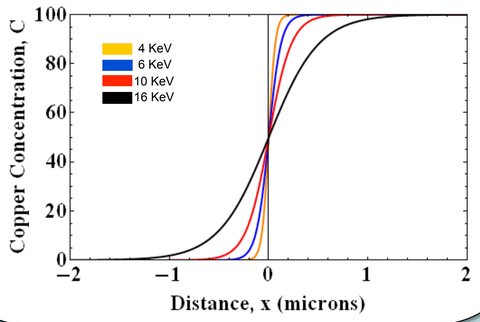
MONTE CARLO SIMULATIONS: INTERACTION VOLUME EFFECTS

Atomic Number



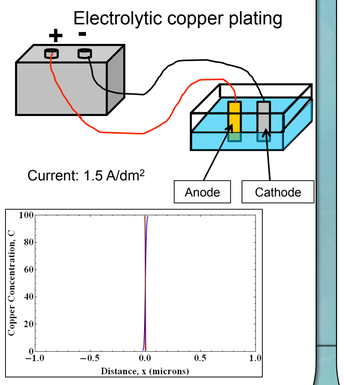
EXPERIMENTAL RESULTS

- XEDS analysis of an ultrasonically consolidated sample at different accelerating voltages shows the effects of the interaction volume on the concentration profiles.



SUBTRACTING INTERACTION VOLUME EFFECTS

- Copper plated concentration profiles established a baseline for interaction volume effects.
- Subtracting the baseline profiles from UC profiles resulted in a vertical line at x=0.



Diffusion during UC is on the nanometer scale!

CONCLUSIONS

- The atomic number and accelerating voltage significantly impact the size of the interaction volume.
- Diffusion during UC is occurring over a much smaller distance (nanometer range) than initially expected.
- It is important to consider the interaction volume effects when measuring concentrations over small distances (~a few microns).

ACKNOWLEDGEMENTS

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