What is Ultrasonic Consolidation?

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.

Experimental Procedure

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

Experimental Results

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

Subtracting Interaction Volume Effects

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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

This work is supported by the Army Research Laboratory through the Composite Materials Research program.