DIFFUSION AS A BONDING MECHANISM DURING ULTRASONIC CONSOLIDATION OF METAL FOILS

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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

Although there are several possible bonding mechanisms, there are many questions regarding the role of diffusion during UC. It is important to characterize diffusion as a bonding mechanism to understand the main influences on bond quality and identify the effect of microstructural changes during the bonding process. Calculating the interdiffusion coefficient provides a means to quantify the extent of diffusion occurring.

**DIFFUSION**

- Diffusion during UC is widely debated due to short weld times and low temperatures.
- Grain boundaries and dislocations provide fast paths for diffusion to occur.
- Activation energies for grain boundary and dislocation diffusion are lower compared to bulk diffusion, leading to higher diffusion coefficients.
- Evidence of subgrains at the weld interface and increased dislocation density with ultrasonic energy supports diffusion during UC.

**EXPERIMENTAL TECHNIQUE**

- Scanning Electron Microscopy (SEM) image of welded interface
- X-ray Energy Dispersive Spectroscopy (XEDS) provides concentration data

**CALCULATION OF THE INTERDIFFUSION COEFFICIENT**

The conc. independent solution to Fick’s 2nd Law was used.

Applying the data to the den Broeder equation, expected values were obtained.

**DEN BROEDER VALIDATION**

- Determine the experimental variability
- Calculate interdiffusion coefficients for an array of process variables
- Isolate the effects of ultrasonic amplitude and temperature
- Study the role of dislocations and grain boundaries

**FUTURE WORK**

**ACKNOWLEDGEMENTS**

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