BONDING MECHANISMS AND CHARACTERIZATION OF METAL MATRIX COMPOSITES USING ULTRASONIC CONSOLIDATION

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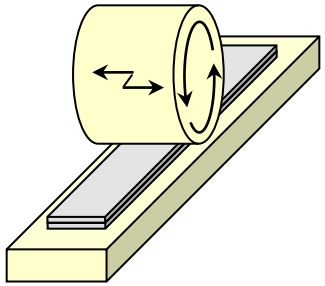
WHAT IS ULTRASONIC CONSOLIDATION?

- 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 similar to tape placement for thermoplastic composites.
- Advantages over other traditional MMC processing methods:
  - Low processing temperatures minimize residual stresses in the material and changes in the microstructure
  - Ability to weld dissimilar materials
  - Fast production times

PROCESSING TECHNIQUE

- Metal foils or prepreg tapes are placed on top of a stationary anvil and a rotating horn travels the length of the foils.
- Three machine variables are used during the processing and influence the resulting bond between foils:
  - Applied normal force or load
  - Oscillation amplitude
  - Welding speed



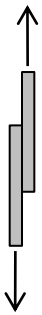
POTENTIAL BONDING MECHANISMS

- Removal of surface oxide layer between foils through oscillating and normal forces
- Formation of bonds across the interface

Possible Mechanisms	Description
Plastic Deformation	Metal matrix flow caused by dislocation movement
Diffusion	Transfer of mass across an interface
Acoustic Softening	Ultrasonic energy causes a reduction of stress for plastic deformation
Mechanical Interlocking	Metal flows into irregularities and locks mechanically
Interfacial Metal Melting	Molten metal flow at the interface
Atomic Attraction	Materials brought within atomic distances are attracted to each other

MECHANICAL TESTS FOR BOND QUALITY

- Previous studies have shown that bond strength can exceed the tensile strength of the base metal
  - Tensile failure occurs within a single foil rather than the weld interface
  - Lap-shear tests with fiber reinforced MMC tapes are currently being explored as a viable technique to measure shear strength of ultrasonically consolidated tapes

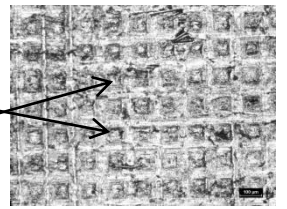


MICROSCOPY OF WELD INTERFACE

- Optical microscopy shows full consolidation of UC MetPreg™ tapes (alumina fiber reinforced aluminum matrix prepreg manufactured by Touchstone Research Laboratory)

SURFACE ROUGHNESS

Impressions from the knurl pattern on the horn



- These impressions increase the surface roughness of the tapes, which will impact friction and heat generation for welding additional layers

FUTURE WORK

- Find processing window for optimal shear strength using design of experiments and lap-shear testing
- Further investigate and explore bonding mechanisms
- Determine if full consolidation occurs in multi-layer composites

ACKNOWLEDGEMENTS

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