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Joining Innovation

Ultrasonic Brazing

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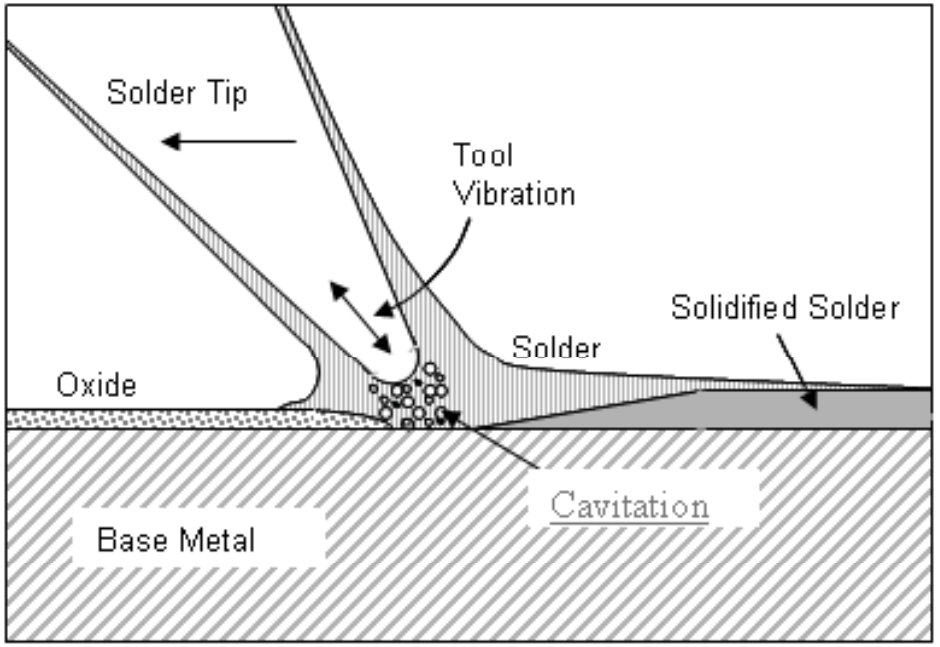
Mechanics of Presentation

- Background on ultrasonic soldering
- Motivation
- Program Objectives
- Experimental
- Results
- Summary

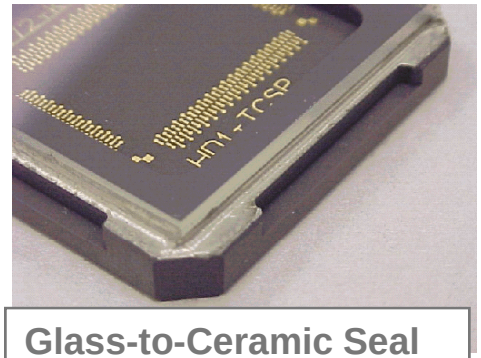
Background on Ultrasonic Soldering

- Decades old technology
- Ultrasonic soldering is the process of pretinning or metallizing the surface of any material without flux
- Cavitation mechanism
- Benefits of flux elimination
  - Cost of flux and post-solder cleaning operations
  - Elimination of potentially hazardous exposure
  - Elimination of corrosion due to flux residue
- This process also obviates the use of platings on difficult-to-wet materials



Ultrasonic Soldering at EWI

- Dissimilar materials
- EWI SonicSolder™
- Various frequencies
- Customized tool design

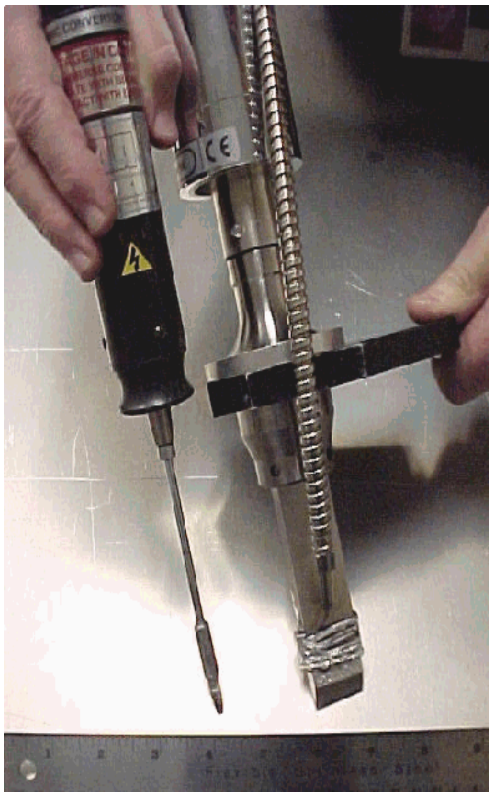


Glass-to-Ceramic Seal

25-mm SiC to Ti-6-4

Nitinol Ribbon (0.0014- × 0.006-in.) to Nitinol Tube (0.008-in. OD)

Glass-to-Metal Joint



Commercial Unit (left) vs. EWI Design (right)

EWI 25 YEARS Years of Joining Innovation

Motivation

- Ultrasonic Soldering is currently limited by the relatively low melting point of solders, and associated lower strengths (for e.g., 231°C for EWI's Sn-Al SonicSolder™, and its strength- 4-5 ksi in shear).
- Benefits of ultrasonic brazing
  - Allow brazing in air without flux.
  - Permit brazing of non-metals without metallizing/plating
  - Enable reflow brazing of components and applying metallizations that have melting temperatures greater than those of solders (>450°C).
  - Attain shear strengths greater than those obtained with solders (2-5 ksi).

Program Objectives

- Develop and demonstrate ultrasonic brazing process
  - Higher temperatures
  - Different part geometries
  - Dissimilar materials
- Define best practices and process envelope for high-temperature ultrasonic brazing

Experimental

- **Joint Geometry:** Single lap (flat geometry)
- **Substrates**
  - Similar Metals: 304 SS, Ti-6Al-4V
  - Dissimilar Materials: Boron Carbide to Steel
- **Filler Metals**
  - Al-12Si (Brazing temperature~600C)
  - Al (Brazing Temperature ~700C)
- **Single lap dimensions:** 2” x 1” x ¼” with 1” overlap

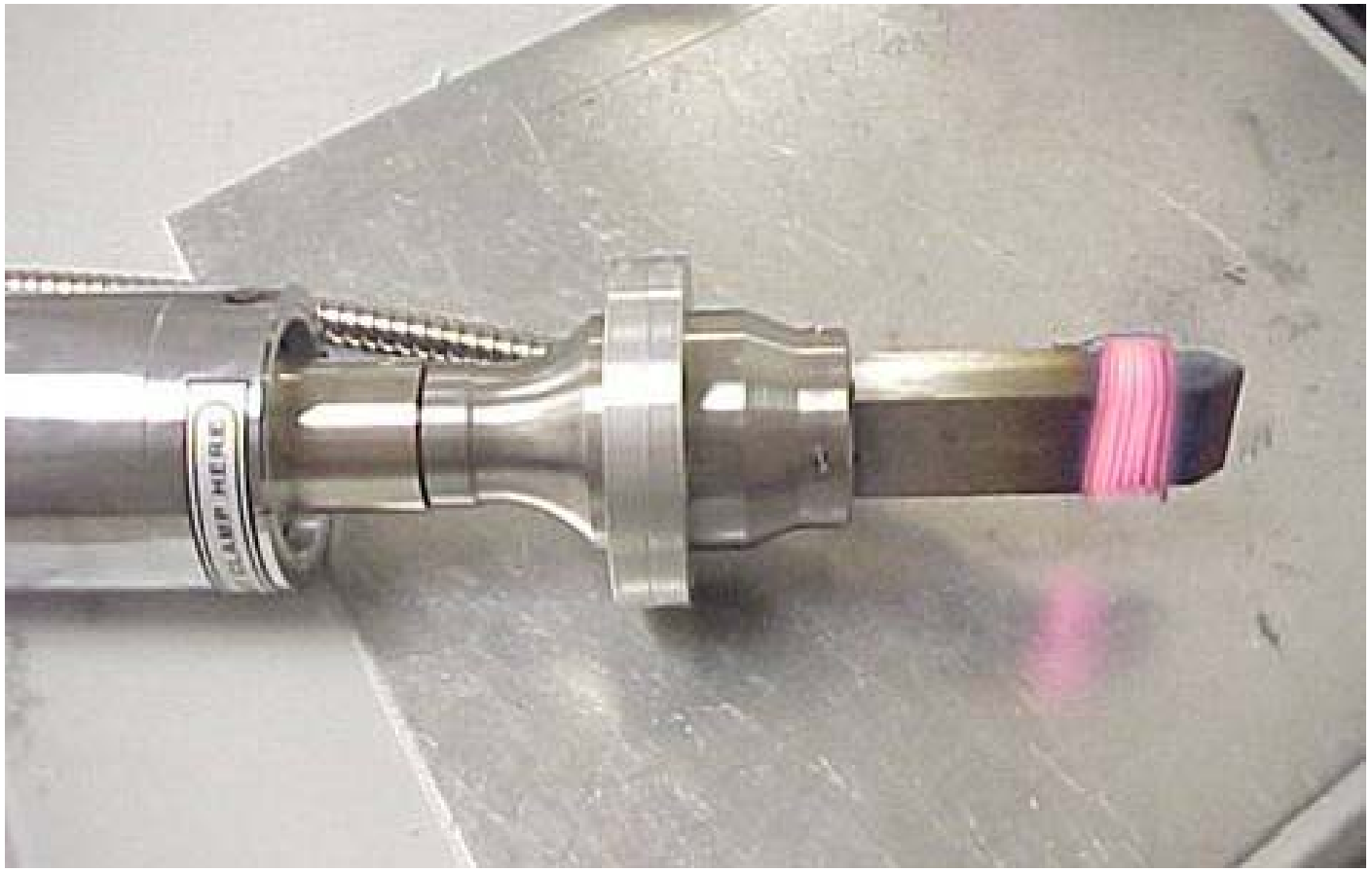
- **Tubular**: Dissimilar Metal Brazing of 321SS -17-4PH steel

- **Brazing atmosphere:** Air

Ultrasonic Brazing

- **Sonotrodes:** Stainless steel horn tuned to operate at brazing temperatures
- **Ultrasonic Brazing:** 30 KHz, 350 W power, 70% amplitude
  - Ultrasonically pretin/metallize both surfaces with the molten filler metal
  - Reflow on stainless steel jig on hot plate
  - Transfer to RT to form the joint
- **Joint strength evaluation**: Compressive shear

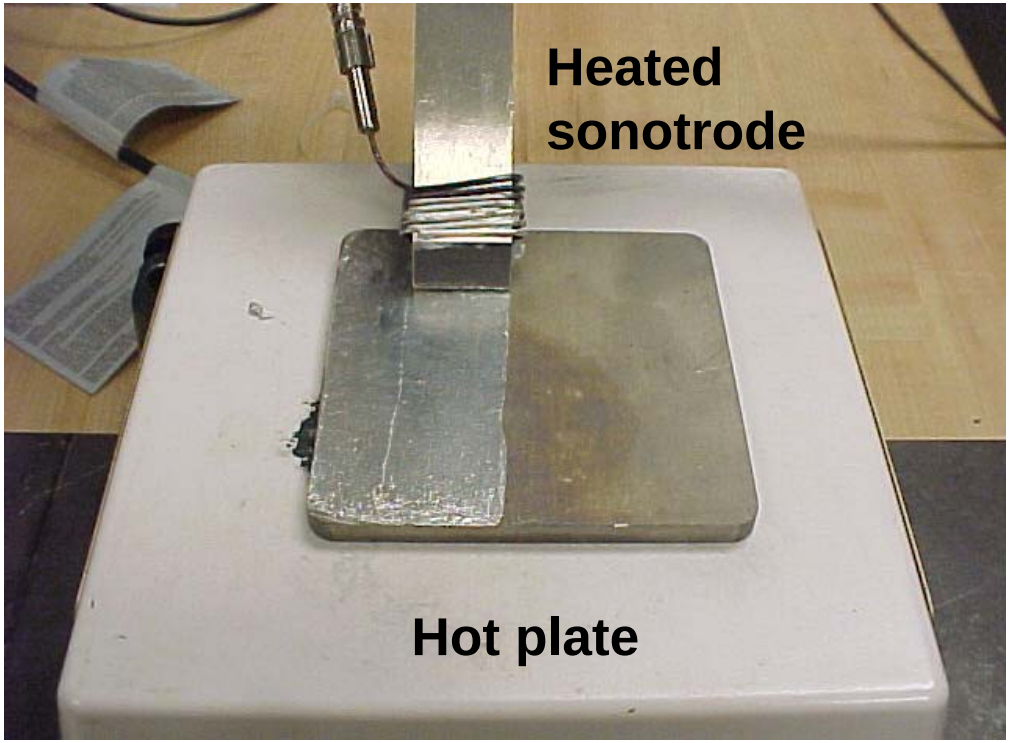
Heated Ultrasonic Sonotrode



Celebrating 25 Years of Joining Innovation
EWI 25 YEARS

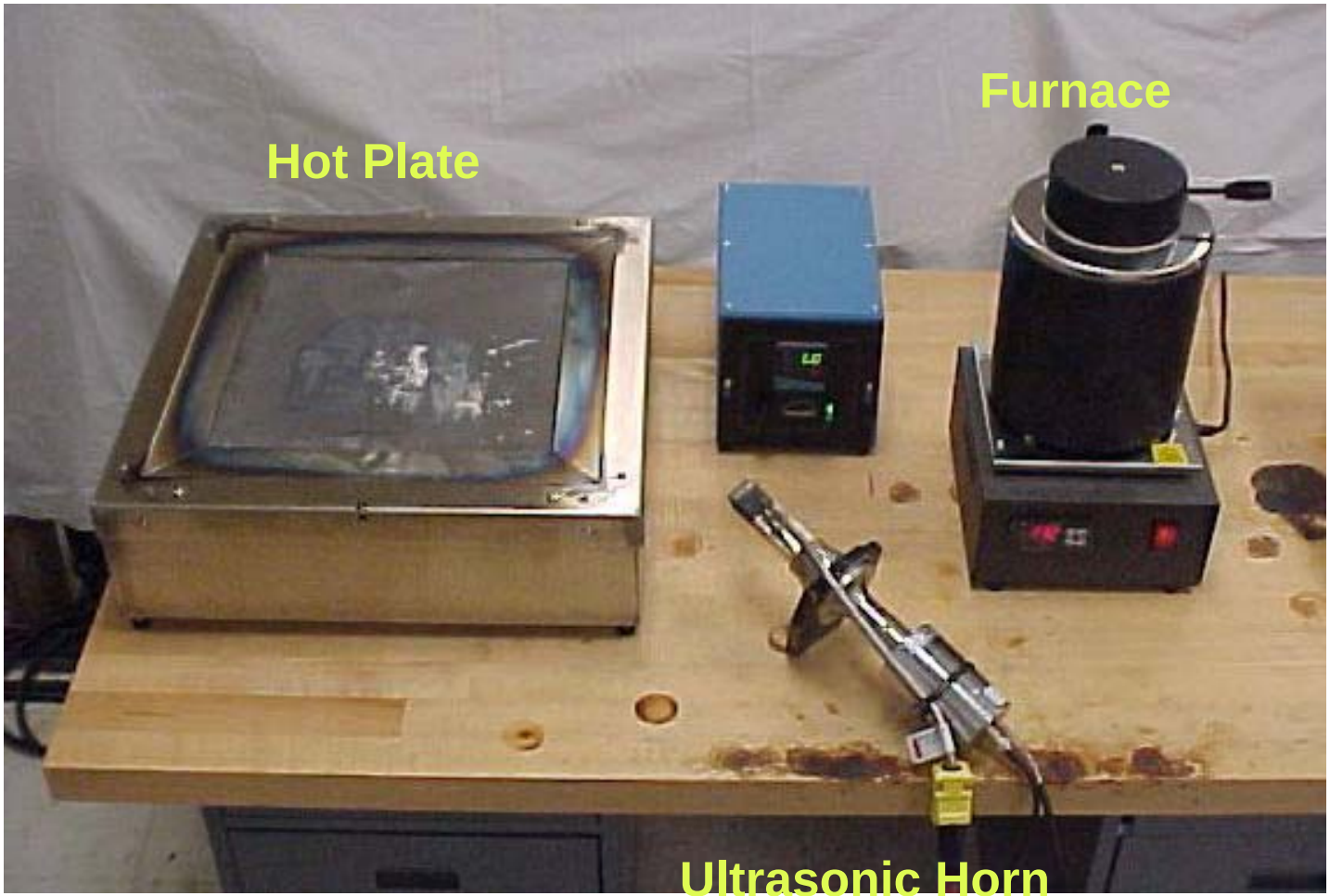
Process Basics

- Preheat the sonotrode
- Preheat the work piece
- Wet the iron with brazing filler metal
- Ultrasonically activate the sonotrode while in contact with the work piece



Ultrasonic pretinning oxidized Ti-6Al-4V

Experimental Set-up



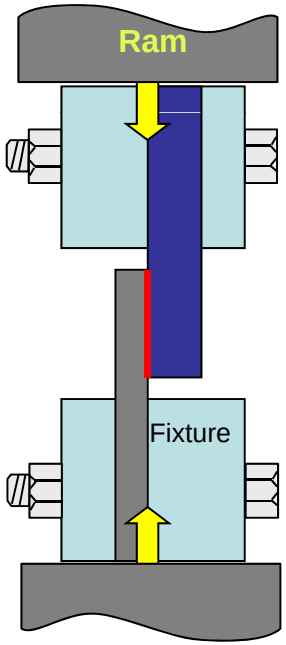
Ultrasonically Brazed Specimens

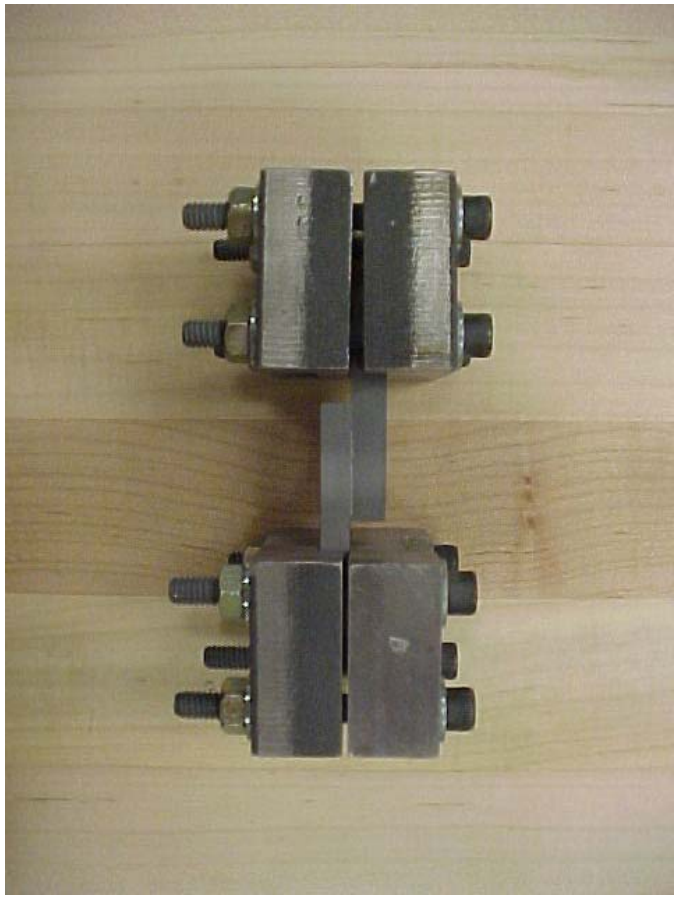
Al-12Si/304 Stainless Steel

Al-12Si/Ti-6Al-4V

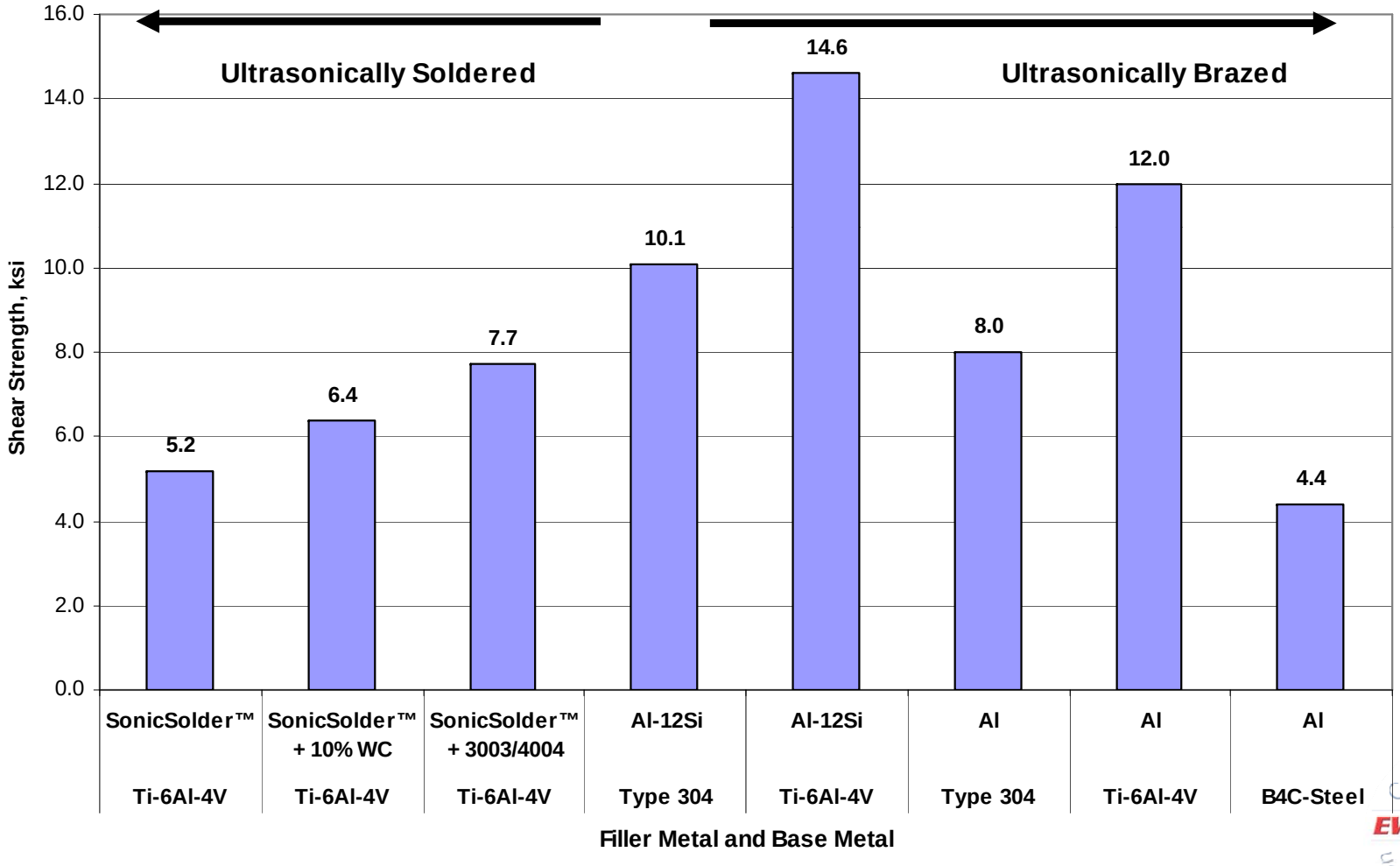
1100 Al/Ti-6Al-4V

Compressive Shear-Test Specimen

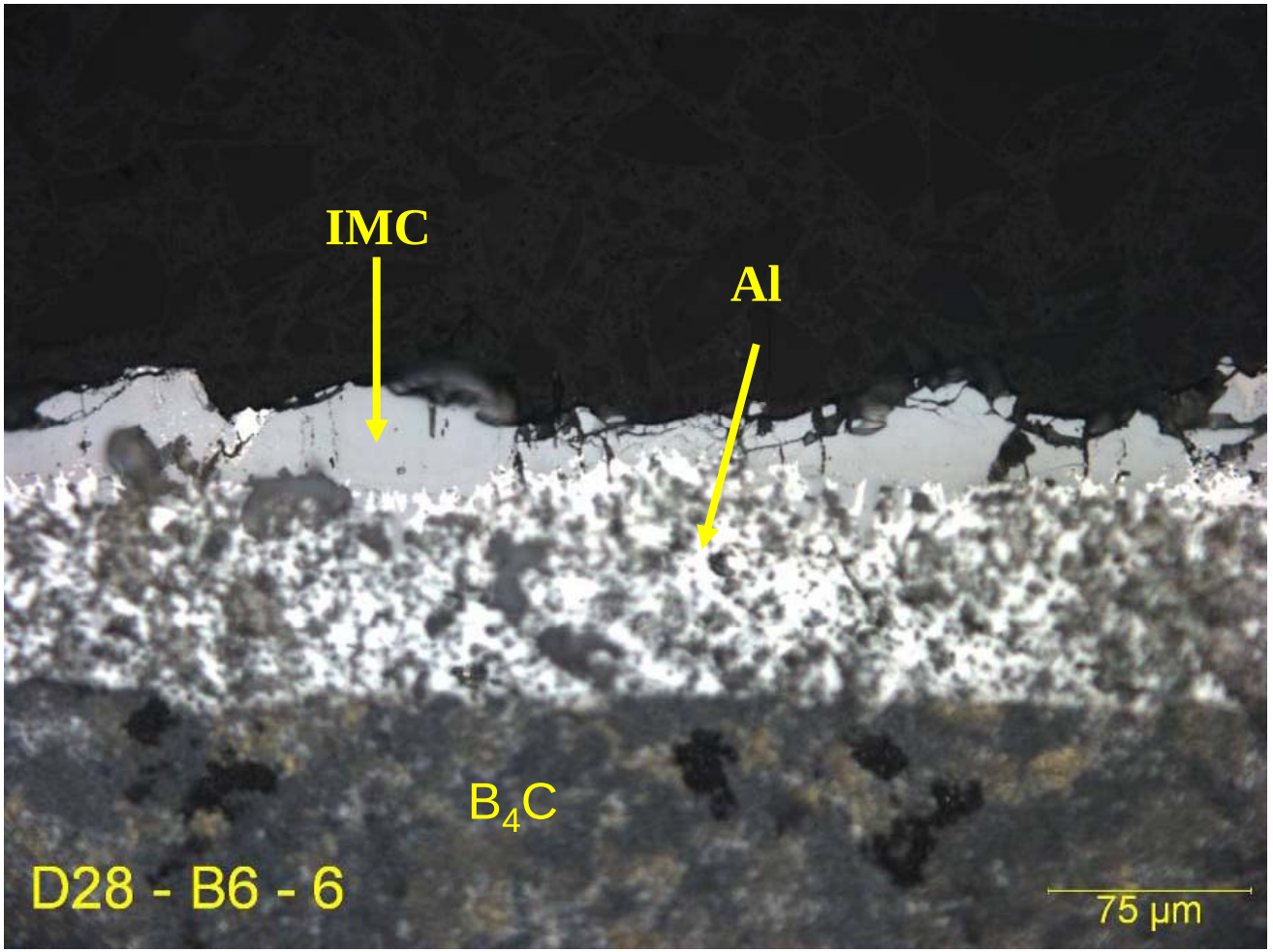




Compressive Shear Strength Data

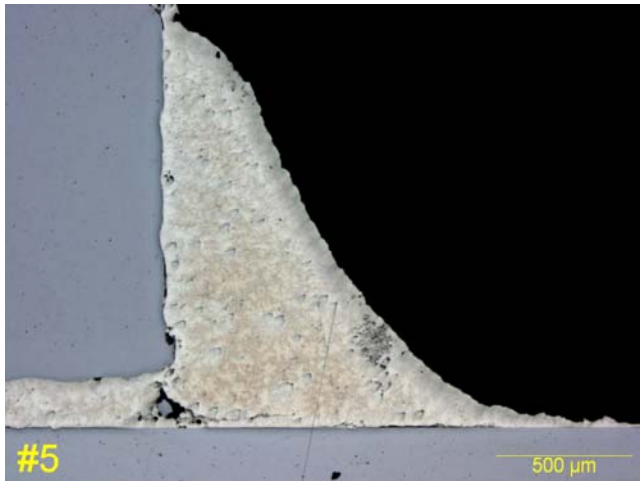


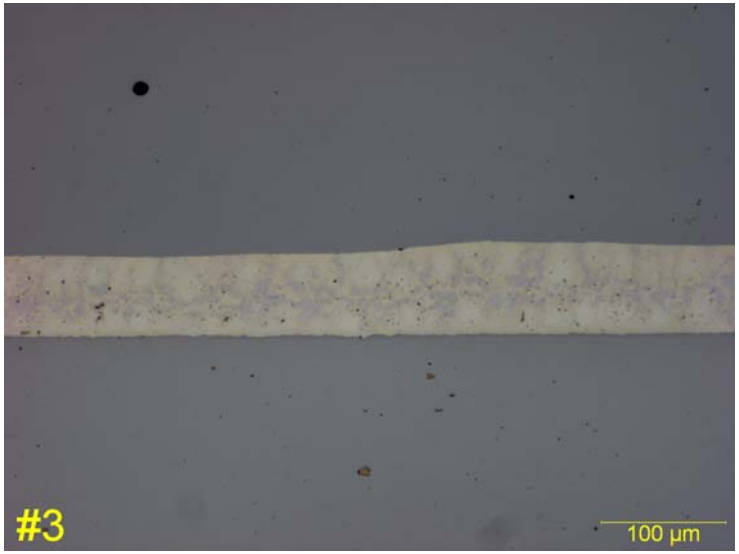
B_4C-Al Filler metal interface



Ultrasonic Brazing of Dissimilar 321 to 17-4PH Stainless Steel Tubing

Type 321 to 17-4PH Stainless Steel





Summary

- Ultrasonic Brazing in air without flux has been demonstrated on similar metals as well as on dissimilar metals and materials including ceramics.
- Ultrasonic brazing in air at ~600C using Al-12Si filler metal has been demonstrated on flat stainless steels and titanium alloys.
- Ultrasonic brazing at ~600C using Al-12Si has also been demonstrated on tubular geometries of dissimilar stainless steels.
- Ultrasonic brazing at temperatures at or greater than 700°C is feasible but oxidation of filler metal appears to result in lower than expected strengths. Brazing at these temperatures may require controlled atmospheres to prevent filler metal oxidation.

Questions

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