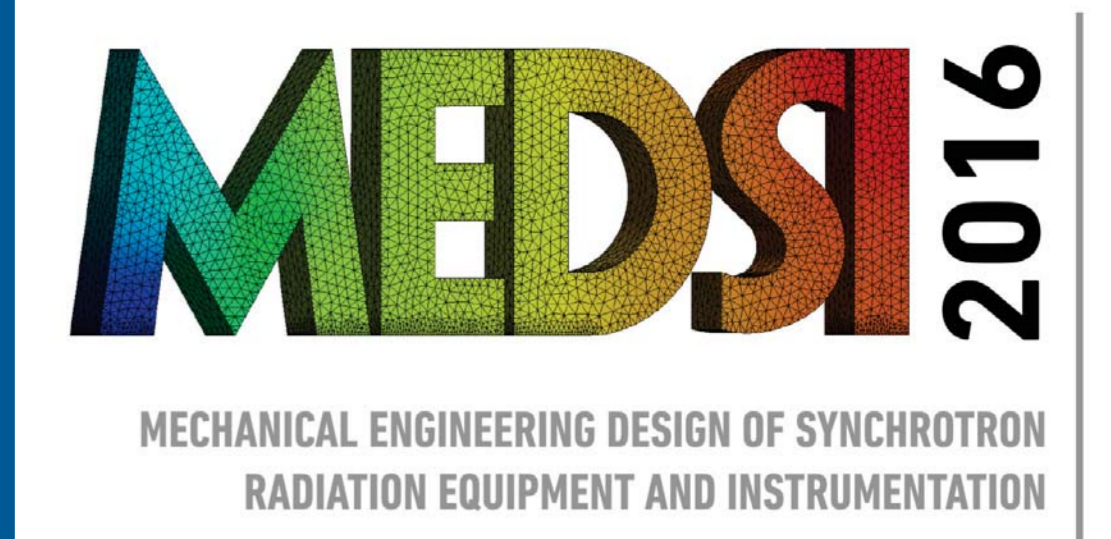


METALLURGICAL EVALUATION OF DISSIMILAR METAL JOINTS



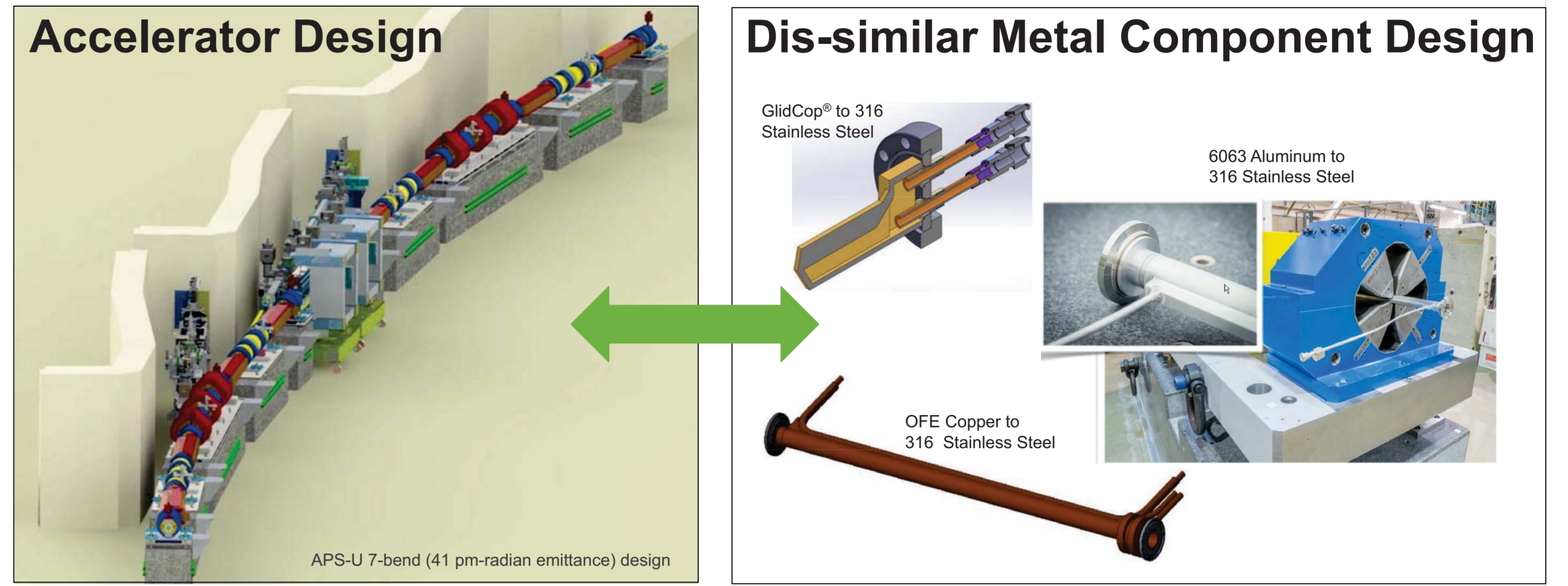
for Accelerator Vacuum Chamber Construction at the APS Upgrade

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ABSTRACT

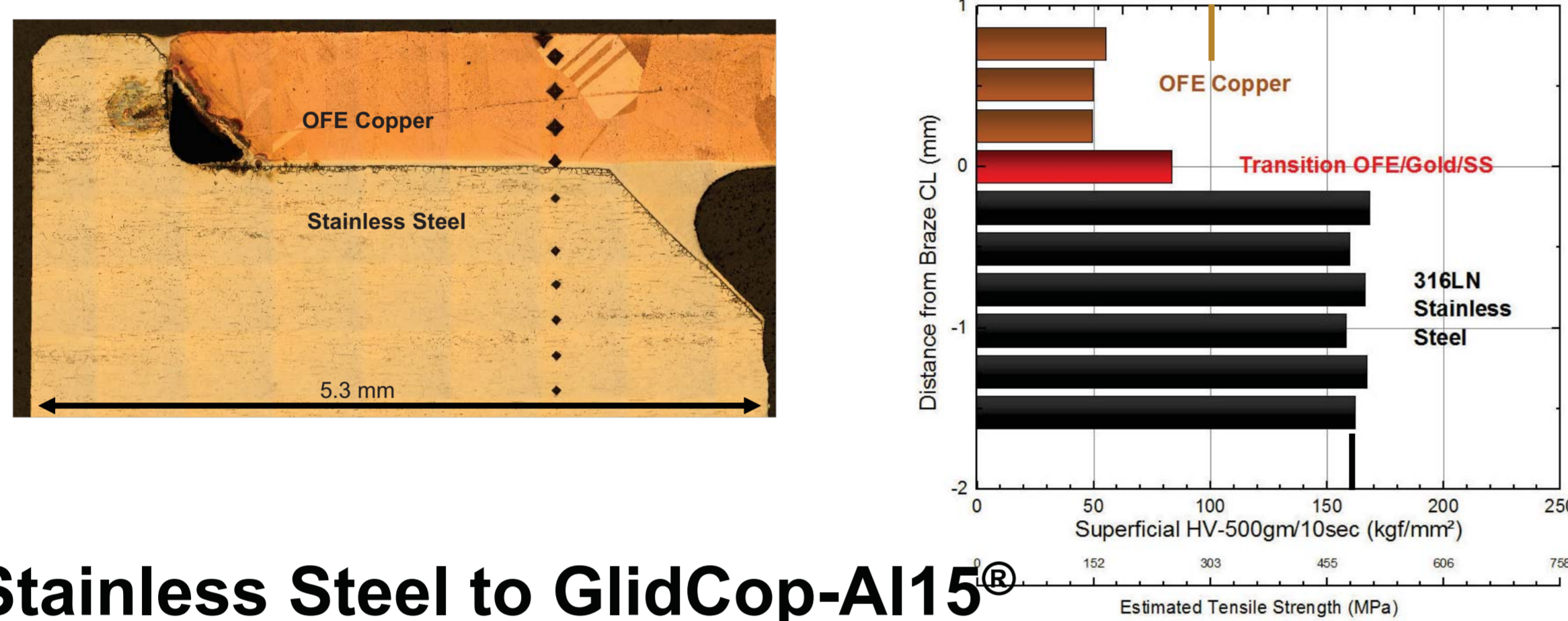
- Tubular vacuum chamber assemblies made of aluminum, copper and stainless steel alloys will be used in the new Multi Bend Achromat (MBA) lattice storage ring complex that is being developed at Advanced Photon Source (APS).
- Ring impedance considerations continue to drive these vacuum chambers to smaller dimensions and thinner walls with tight geometric tolerances under increasing thermal loads.
- It is important to devise methods to join dissimilar metal components without compromising their primary strength, permeability, electrical and thermal properties.
- This poster visually details the metallurgical changes that occur when joining various combinations of aluminum, OFE copper, GlidCop® and stainless steel using brazing, bonding and welding techniques. Each technique has its advantages and disadvantages with engineering and economic consequences.

APS-U MULTI-BEND ACHROMAT

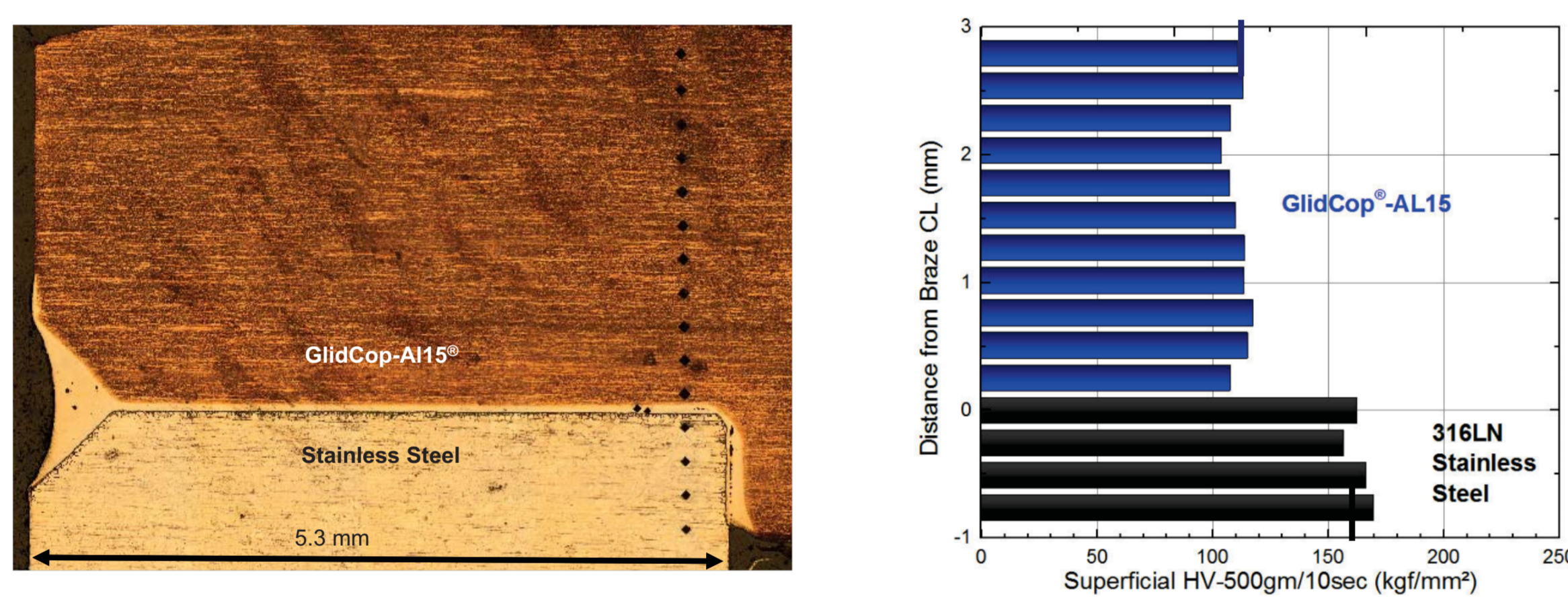


VACUUM BRAZING

- 316L Stainless Steel to OFE Copper

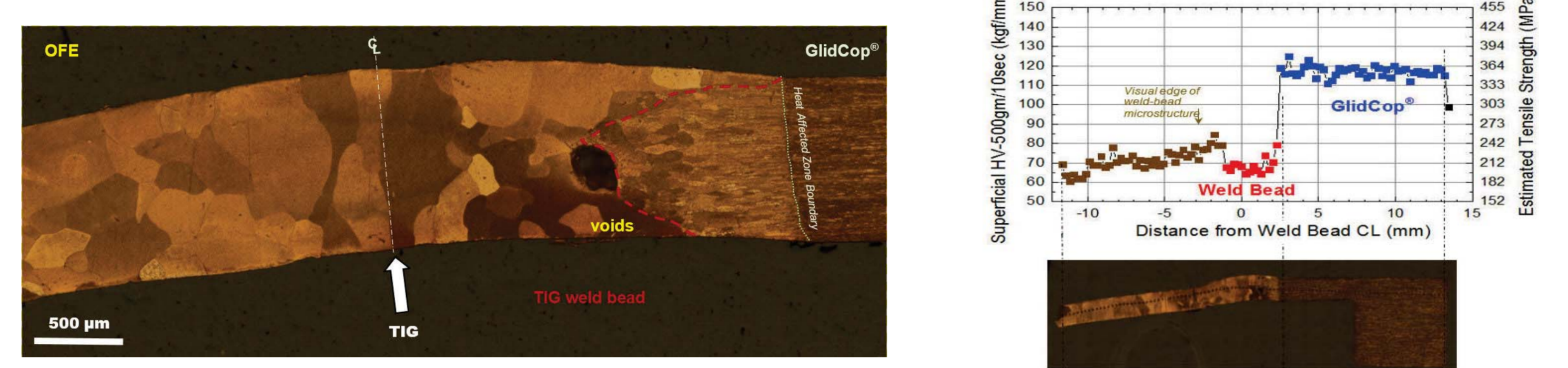


- 316L Stainless Steel to GlidCop-Al15®



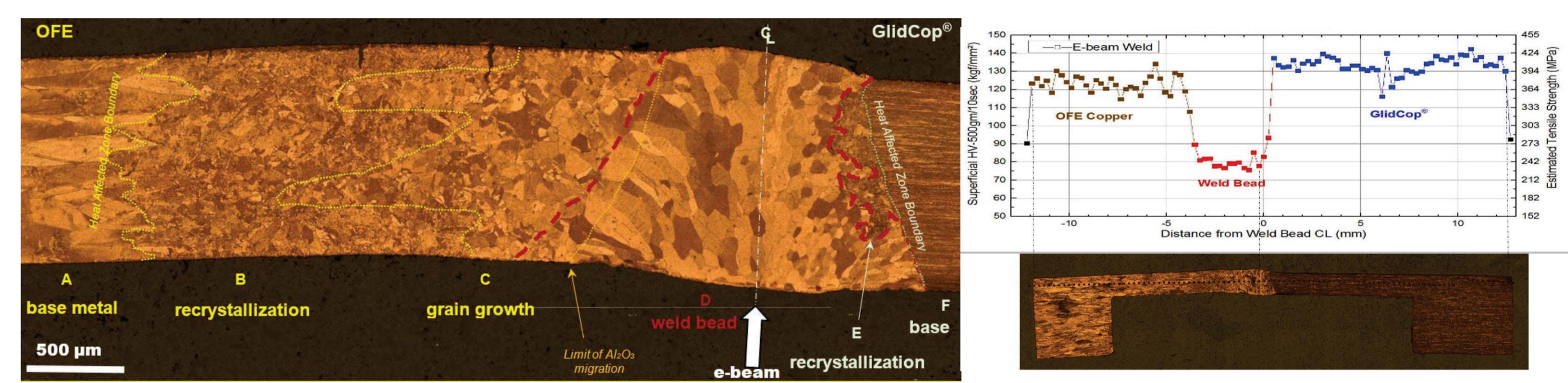
TIG WELDING

- OFE Copper to GlidCop-AL15®



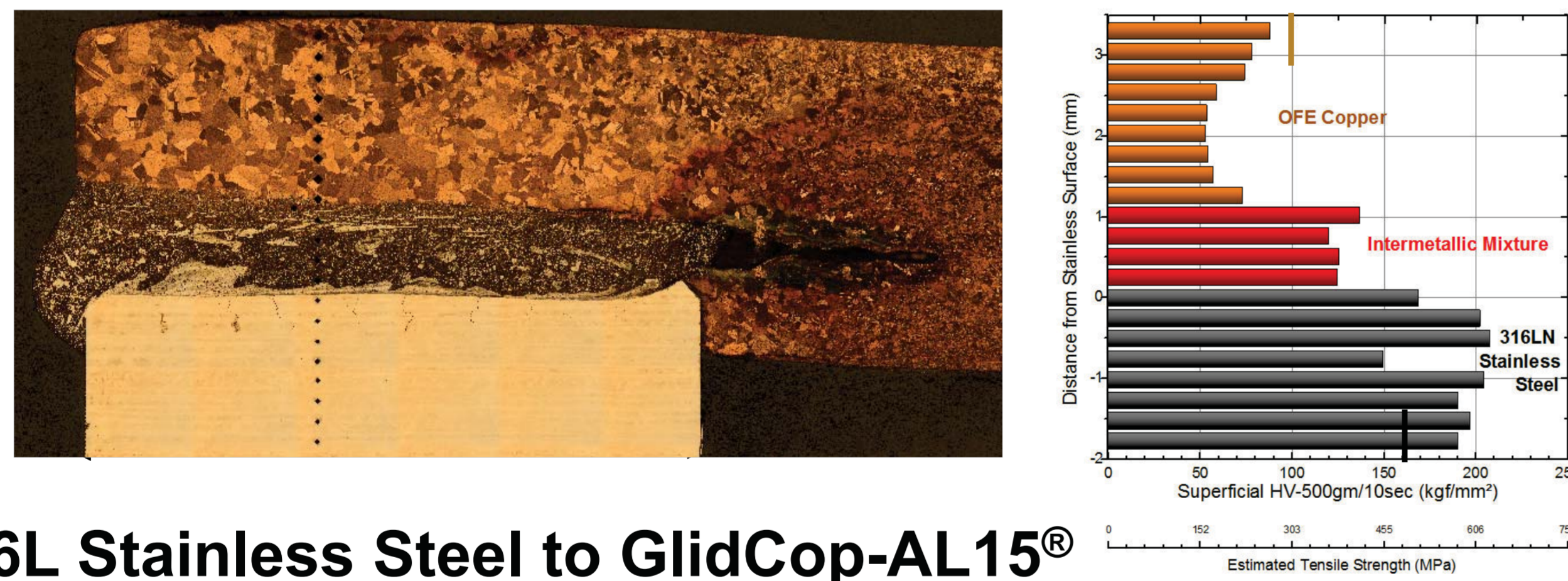
E-BEAM WELDING

- OFE Copper to GlidCop-AL15®



E-BEAM WELDING

- 316L Stainless Steel to OFE Copper

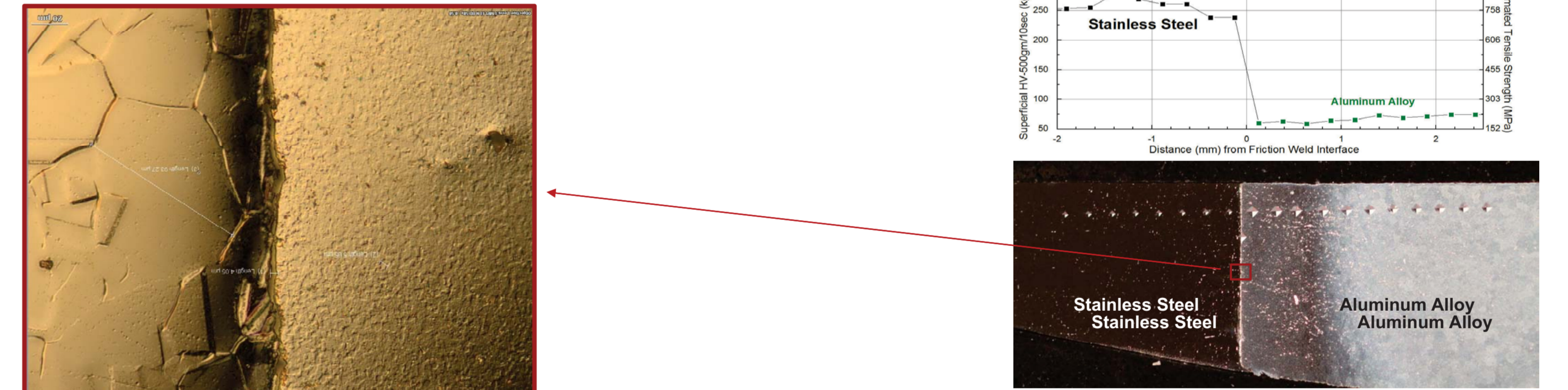


- 316L Stainless Steel to GlidCop-AL15®



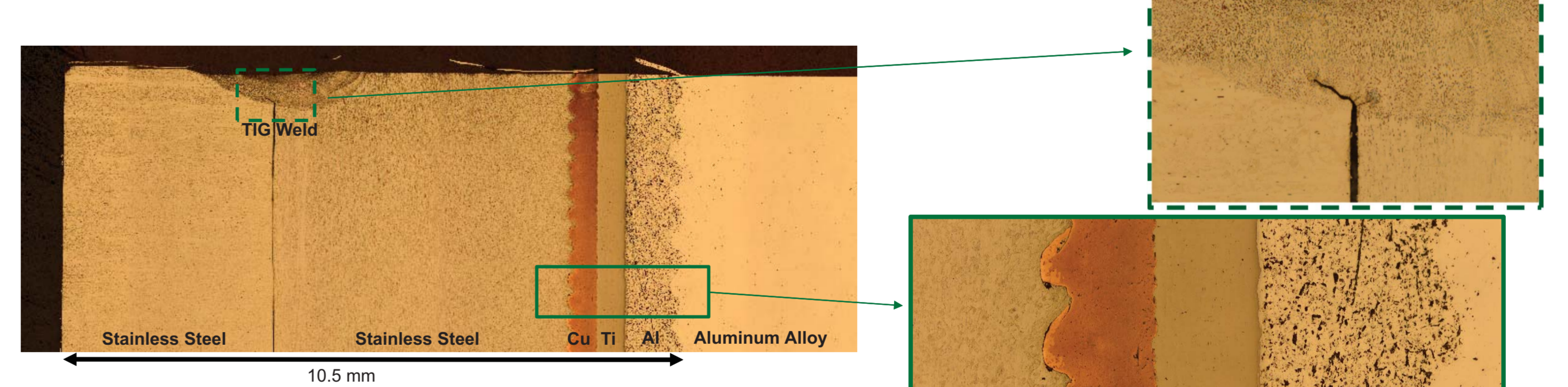
FRICTION WELDING

- 316L Stainless Steel to 6063-T5 Aluminum



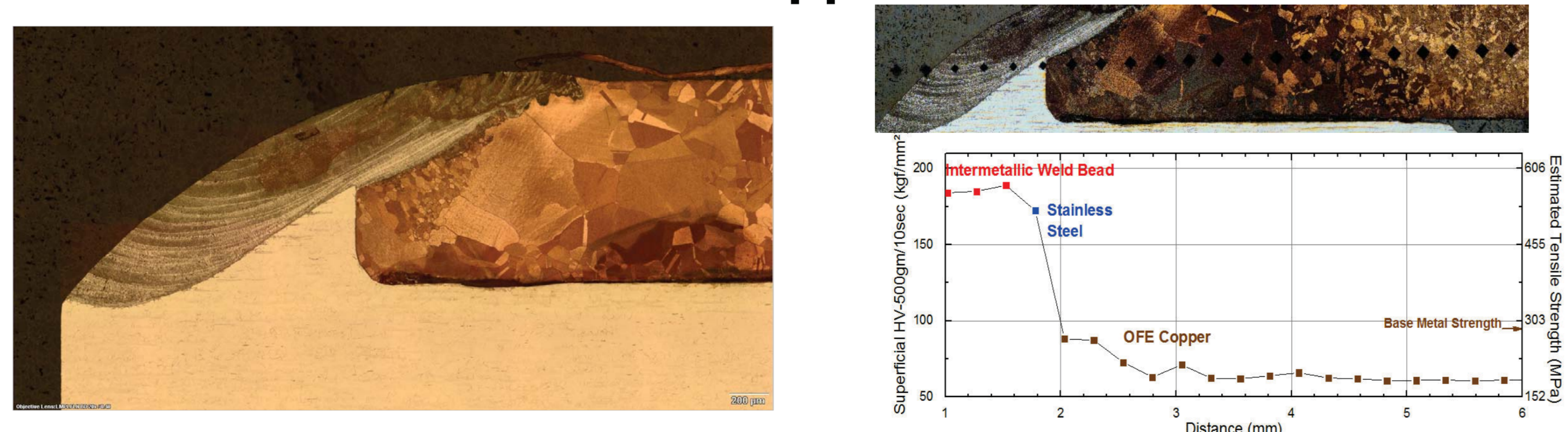
EXPLOSION BONDING

- 316L Stainless Steel to 6063-T5 Aluminum



LASER WELDING

- 316L Stainless Steel to OFE Copper



REFERENCES

- Navrotski, G. "Metallographic Preparation Techniques for GlidCop® Al-15 and OFE Cu for Microstructural Analysis", APS Internal Engineering Report, ICMS #APS_1442674 (2014).
- Work supported by the U.S. Department of Energy, Office of Science, under Contract No. DE-AC02-06CH11357
- Contact: Navrotski@anl.gov

KEY OBSERVATIONS

- **Vacuum brazing:** the 'gold standard' for dissimilar metal vacuum joining.
 - + Well understood, reliable
 - base metals annealed, expensive vacuum furnace
- **Electron beam welding:** + full penetration, narrow heat affected zone - root tip voids, large residual stresses, expensive vacuum welding system, voiding in GlidCop®.
- **Laser welding:** + precise and small heat affected zone. - poor penetration depth
- **TIG welding:** + low cost. - base metal annealed, wide heat affected zone, voiding in GlidCop®
- **Friction welding:** + small heat affected zone, inexpensive - discontinuous fusion zone
- **Explosion bonding:** + only similar-to-similar metal welds - expensive transition explosion bonded metal.