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METALLURGICAL EVALUATION OF DISSIMILAR METAL JOINTS

for Accelerator Vacuum Chamber Construction at the APS Upgrade

MEDSI 2016 — MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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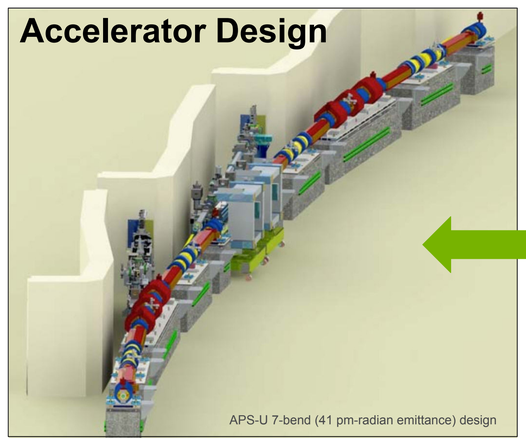
ABSTRACT

- 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

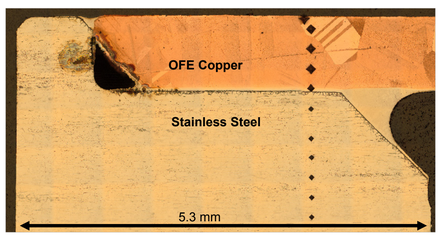
Accelerator Design

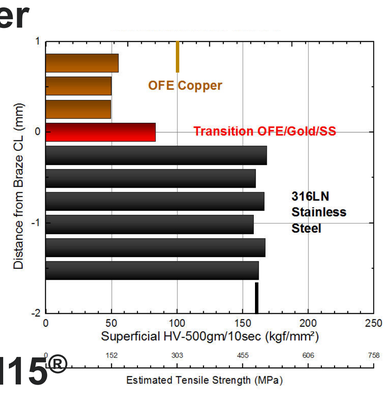


Dis-similar Metal Component Design

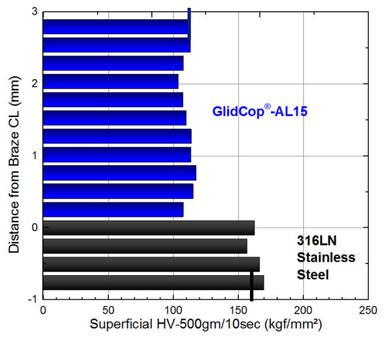
VACUUM BRAZING

316L Stainless Steel to OFE Copper



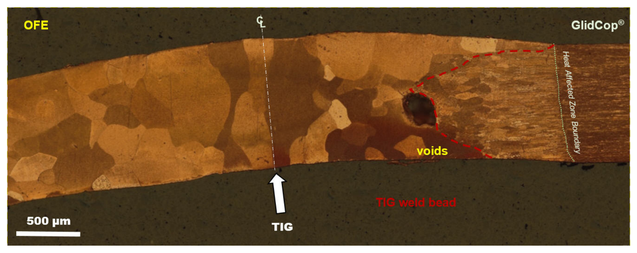


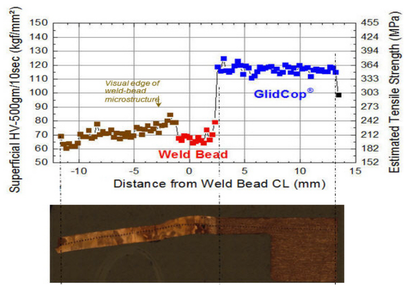
316L Stainless Steel to GlidCop-Al15®



TIG WELDING

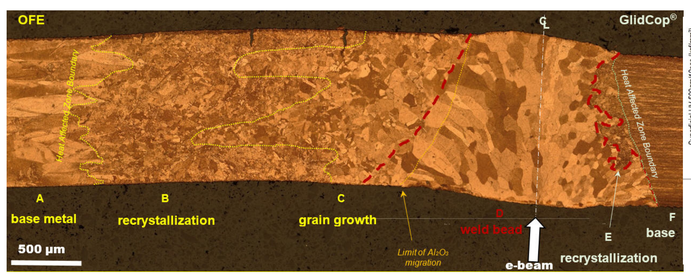
OFE Copper toGlidCop-AL15®

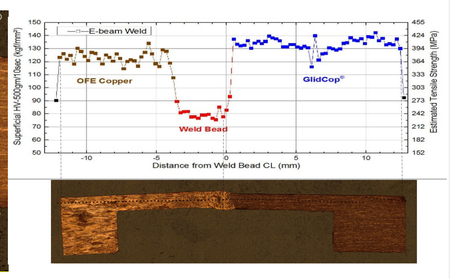




E-BEAM WELDING

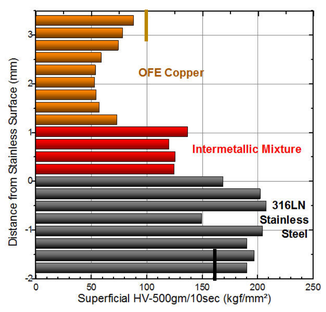
OFE Copper to GlidCop-AL15®



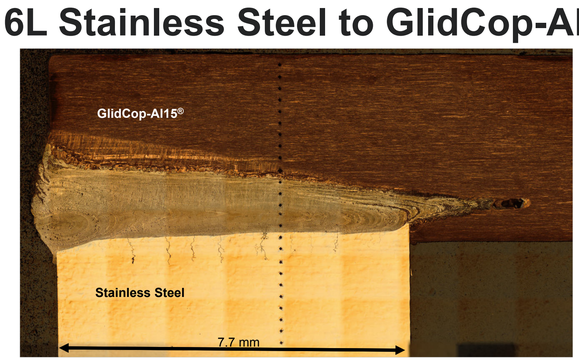


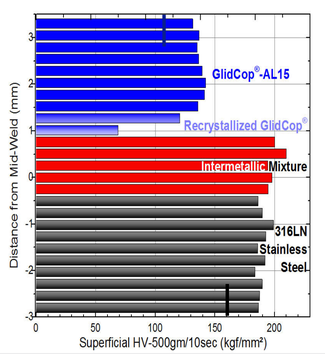
E-BEAM WELDING

316L Stainless Steel to OFE Copper



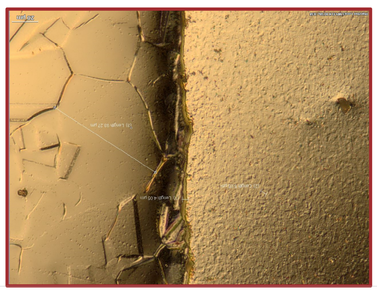
316L Stainless Steel to GlidCop-AL15®

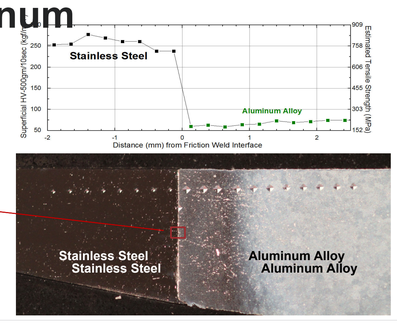




FRICTION WELDING

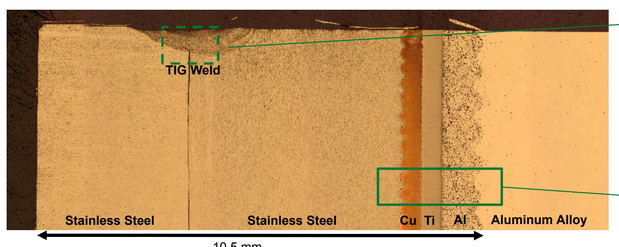
316L Stainless Steel to 6063-T5 Aluminum

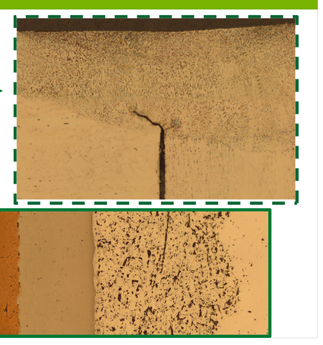




EXPLOSION BONDING

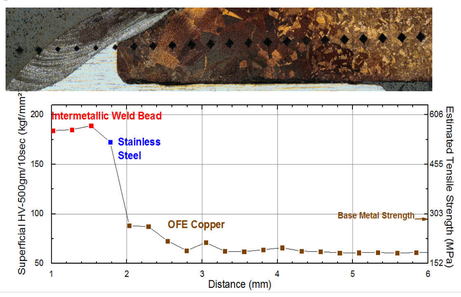
316L Stainless Steel to 6063-T5 Aluminum





LASER WELDING

316L Stainless Steel to OFE Copper



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.

REFERENCES

- Navrotski, G. *"Metallographic Preparation Techniques for GlidCop® Al-15 and OFE Cu for Microstructural Analysis"*, APS Internal Engineering Report, ICMS #APS_1442674 (2014).

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