Assessment of Joint Clearance Sensitivity for a New Brazing Filler Alloy

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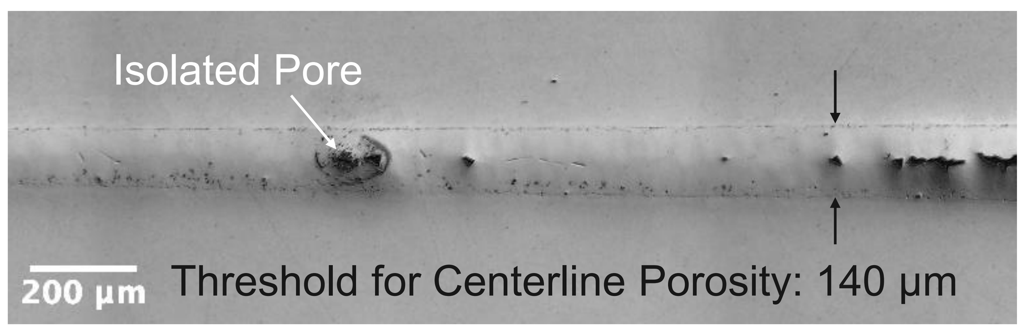
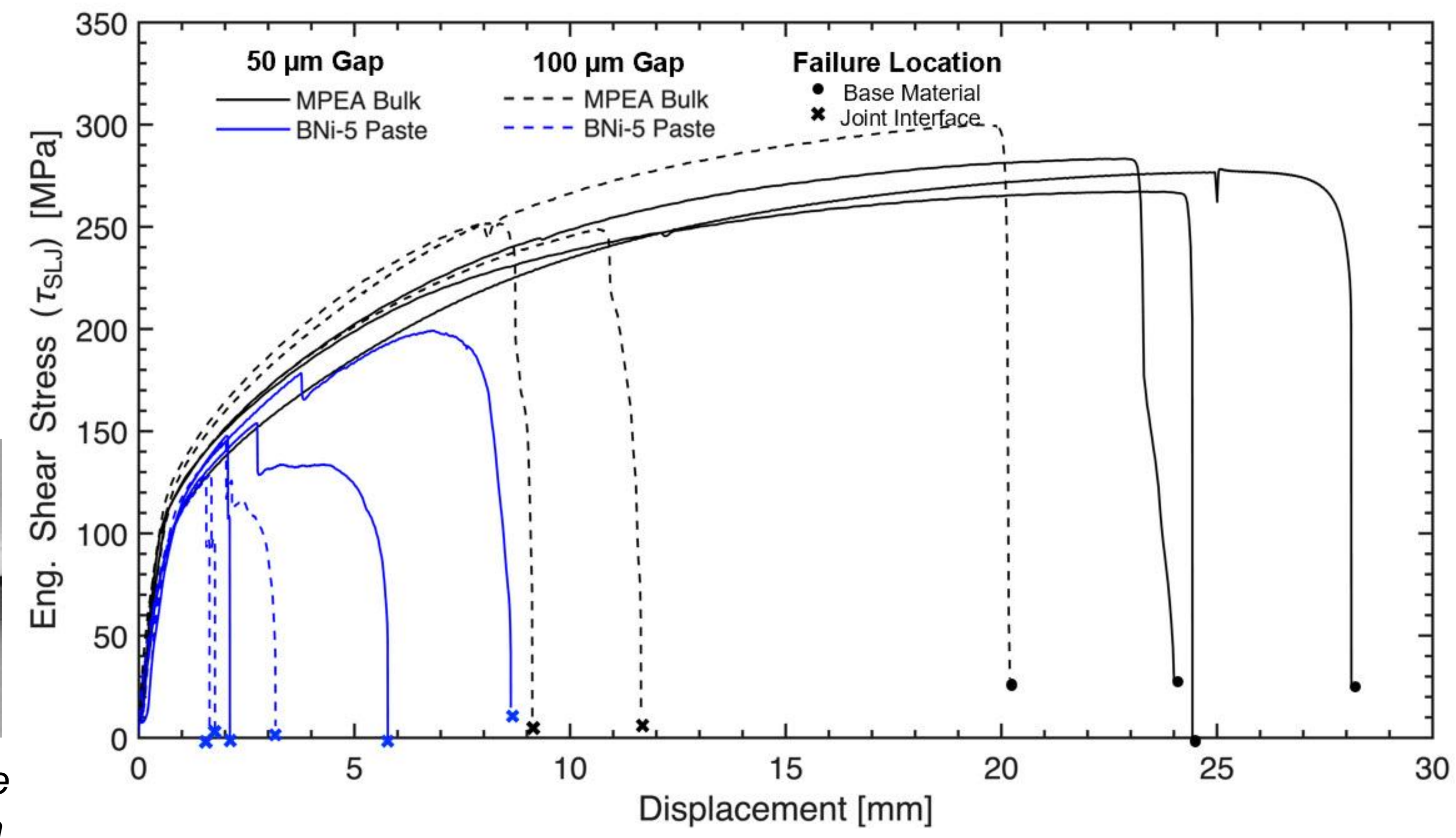
Problem Statement and Objective

- Joint clearance determines the capillary pressure driving the liquid flow into the brazing gap. It also governs mechanical strength of a brazed joint by inducing plastic constraint on the filler metal, owing to the typical higher strength of the surrounding base metal. [1]
- At fixed joint clearances of 50μm and 100μm gaps on 316L stainless steel substrate, a new multi-principal element alloy (MPEA) developed in our previous work [2] exhibited enhanced mechanical behavior in comparison to BNi-5.
- However, the MPEA filler exhibited [2] centerline defects at large gap size (e.g. centerline porosity).
- The objective of this work is to evaluate the flowability and defect formation of the new MPEA filler alloy as a function of joint clearance using a variable-gap T-joint configuration with optimal braze parameters.



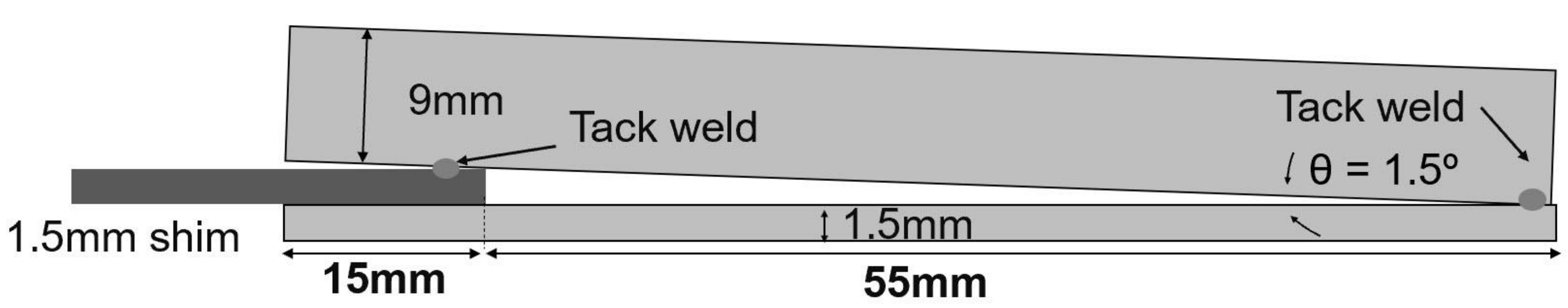
316L substrate brazed with the new MPEA filler paste applied along the joint gap parallel to length direction



Stress Strain Curve of BNi-5 vs. MPEA Shear [2]

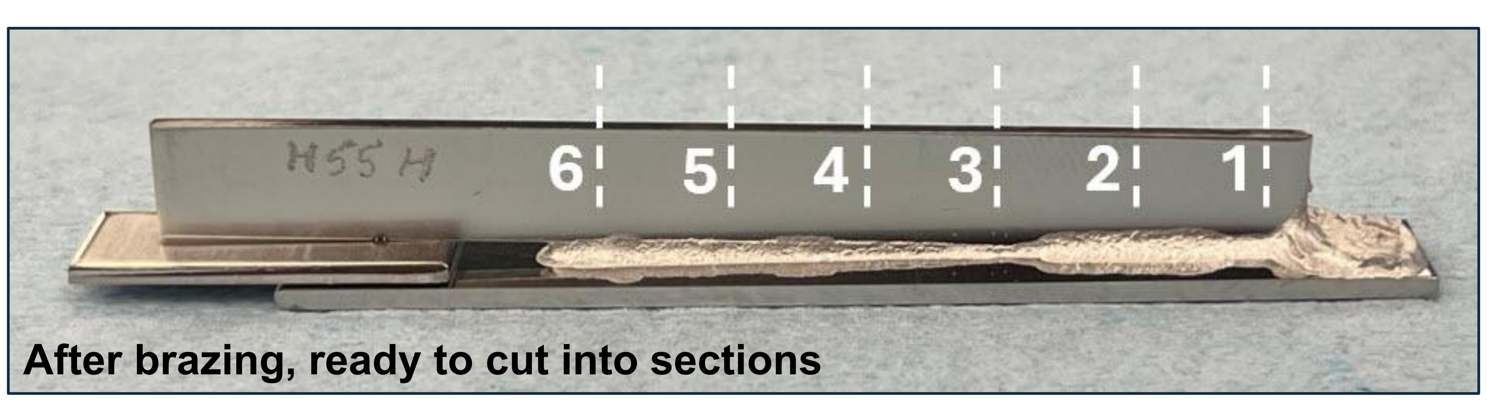
Methodology

- A single T-joint specimen was designed to reveal the brazeability of the new MPEA filler as a function of clearance gap in comparison to BNi-5.
- The stem is laser tack welded onto the flange on both ends and both sides.



- Filler paste with 2x the volume of the gap was applied at the touching end to evaluate the flowability of the filler into the varying joint clearance.

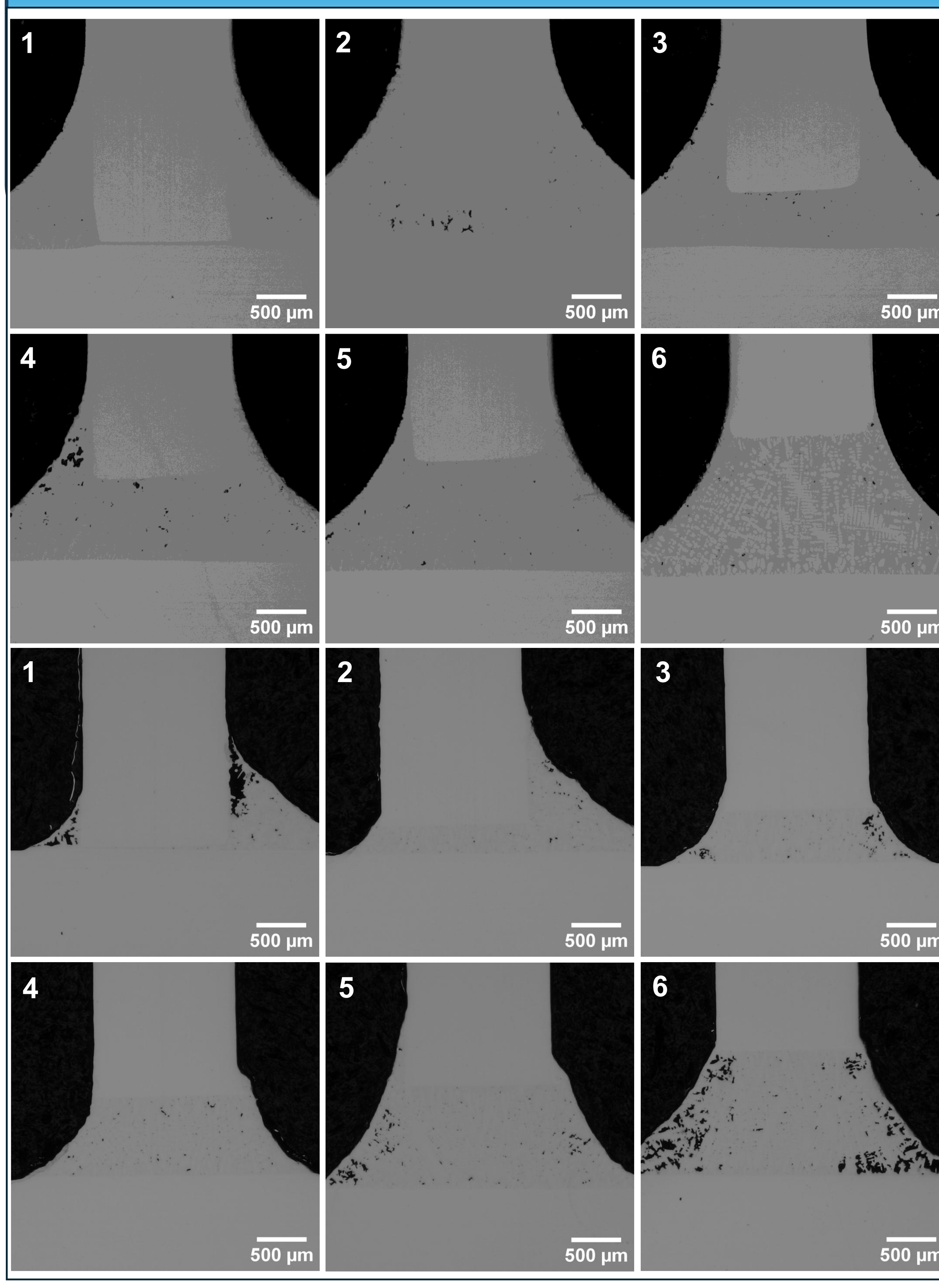
- Parts were heated in a vacuum furnace to a thermal cycle of 15°C/min to 650°C, 60 min at 540°C, 15°C/min to 950°C, 30 min at 950°C, 25°C/min to 1200°C, 2 min at 1200°C.
- The brazed t-joints were cut into 3/8" sections with about 1/8" sections at the ends.



- This table explicitly contrasts the difference in parameters between this methodology designed to reduce voids in the published methodology.

	Published Parameter Set [2]	New Parameter Set
Brazing Hold Time (min)	15	2
Brazing Temp (°C)	1175	1200
Application Site	Along Length	At End
Filler Composition	Published MPEA	Optimized fabrication for contamination control

Profile Results



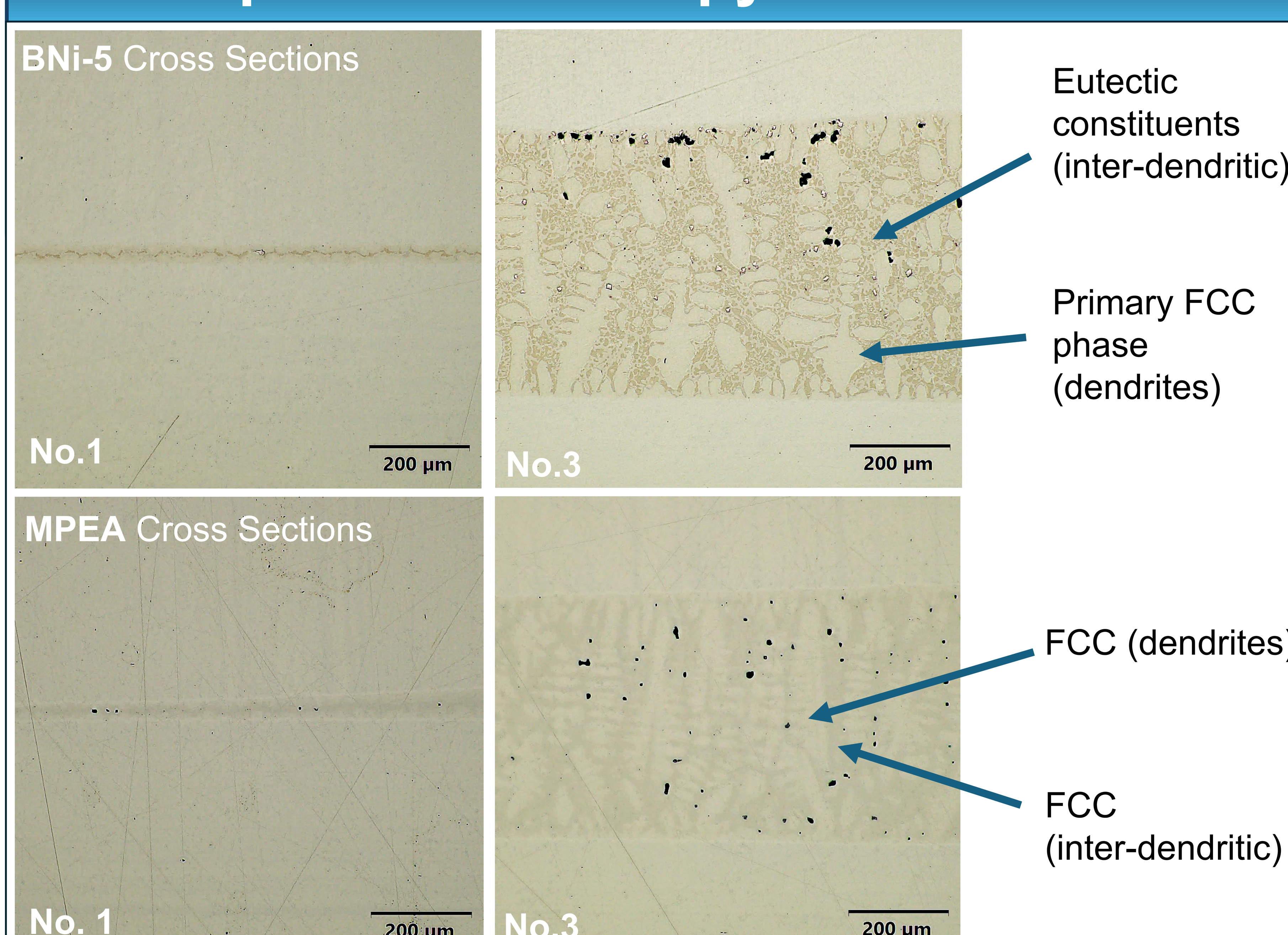
BNi-5 profiles in order of increasing joint clearance. Joint clearance increases with number.

Minimal porosity to greater than 1mm clearance

MPEA profiles in order of increasing joint clearance. Joint clearance increases with number.

More porosity than BNi-5, but far less than observed voids beyond the published 140μm threshold. [2]

Optical Microscopy Examination



- The mechanical degradation observed in BNi-5 shear tests is primarily driven by the brittle, Si-rich eutectic constituents (confirmed by SEM EDS, not shown here). The single-FCC microstructure (confirmed by x-ray diffraction, not shown here) of the MPEA filler significantly enhances joint mechanical performance.

Conclusions and Future Work

- Allowing the MPEA filler to flow into the brazing joint with shorter hold time and elevated temperature resulted in less void defects in a wider clearance compared to prior published work.
- MPEA displayed strong uniform optical microstructure while the BNi-5 contained brittle secondary phases.
- Future work includes mechanical testing at gaps larger than 500μm after brazing using a new parameter set.

Acknowledgements

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References: [1] Brazing Handbook, IV ed., AWS,1991, pp. 12-25. [2] B. Schneiderman, Z. Yu et al., *Welding Journal,* 2026 (In Print).