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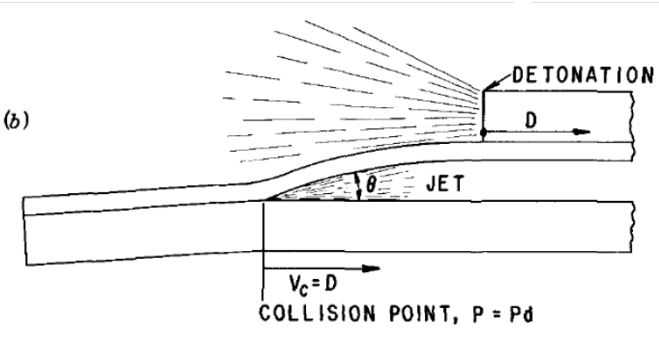

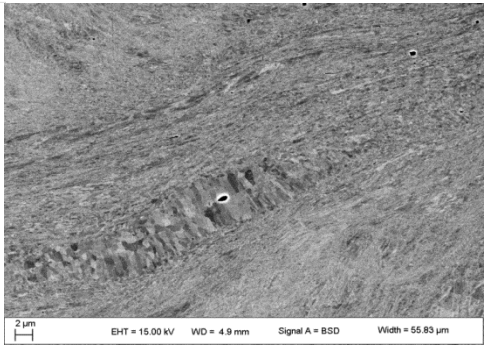

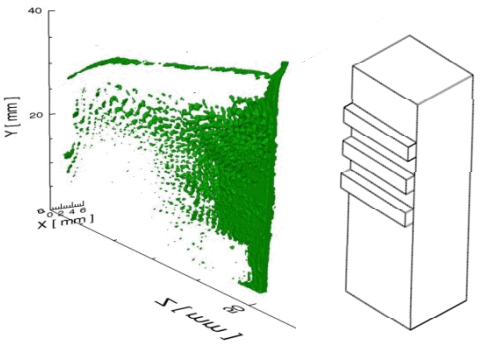

High velocity explosive bonding

Lisa Deibler, Jeff Rodelas

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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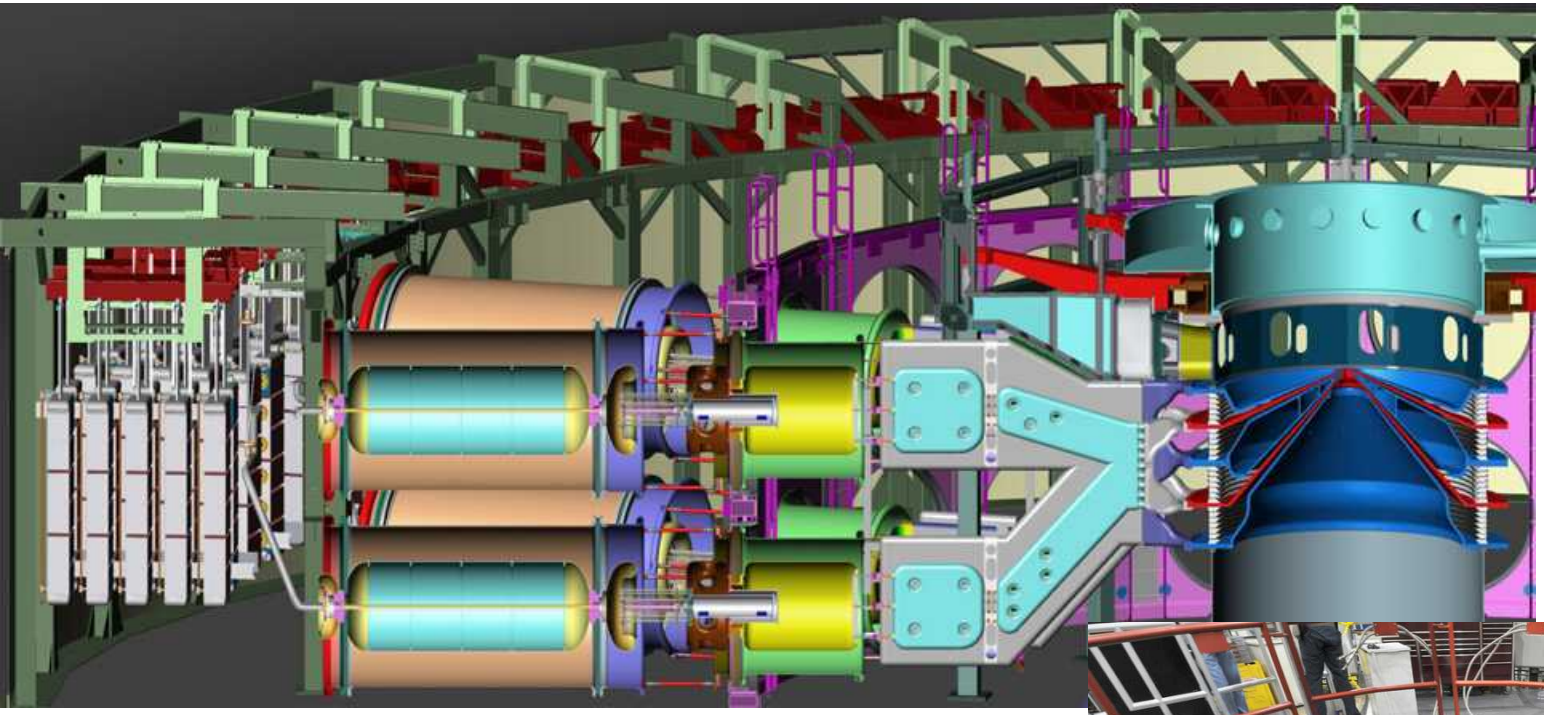
- Pete Wakeland
- Ciji Nelson
- Venner Saul
- Russ Payne
- Alice Kilgo
- Bonnie McKenzie

Sandia's Z-machine

Sandia National Laboratories

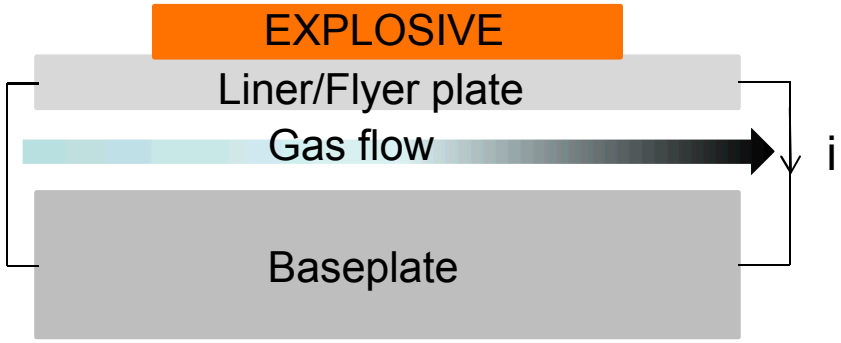
World's most powerful and efficient laboratory radiation source

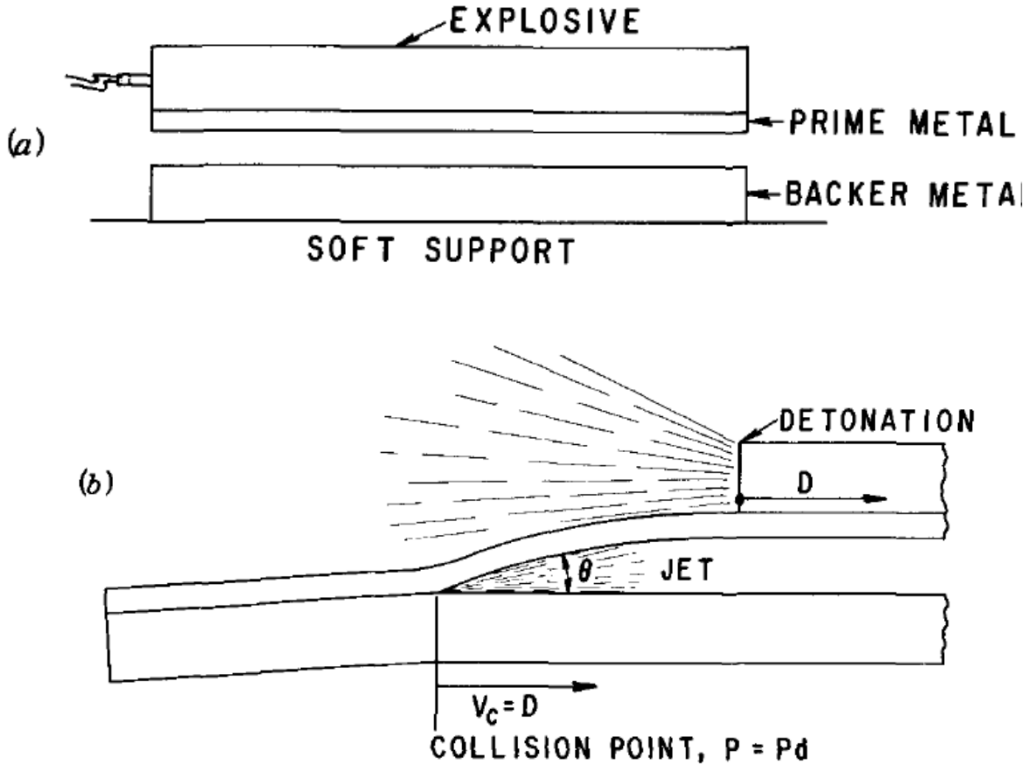


- Fusion
- Materials under extreme environments
- Validation of physics models

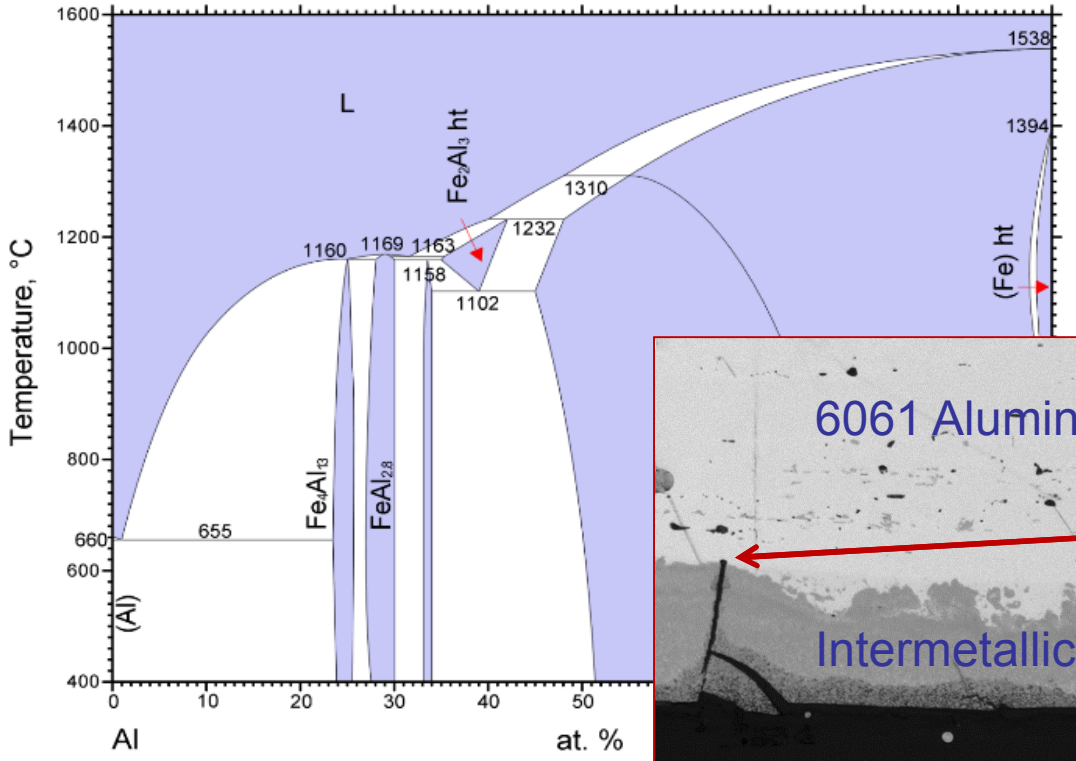
Valve operation

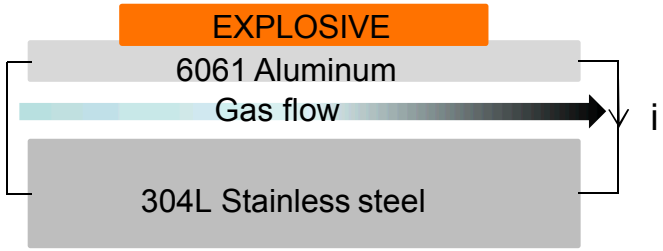
- Seal in < 100 µs
- High explosive velocity

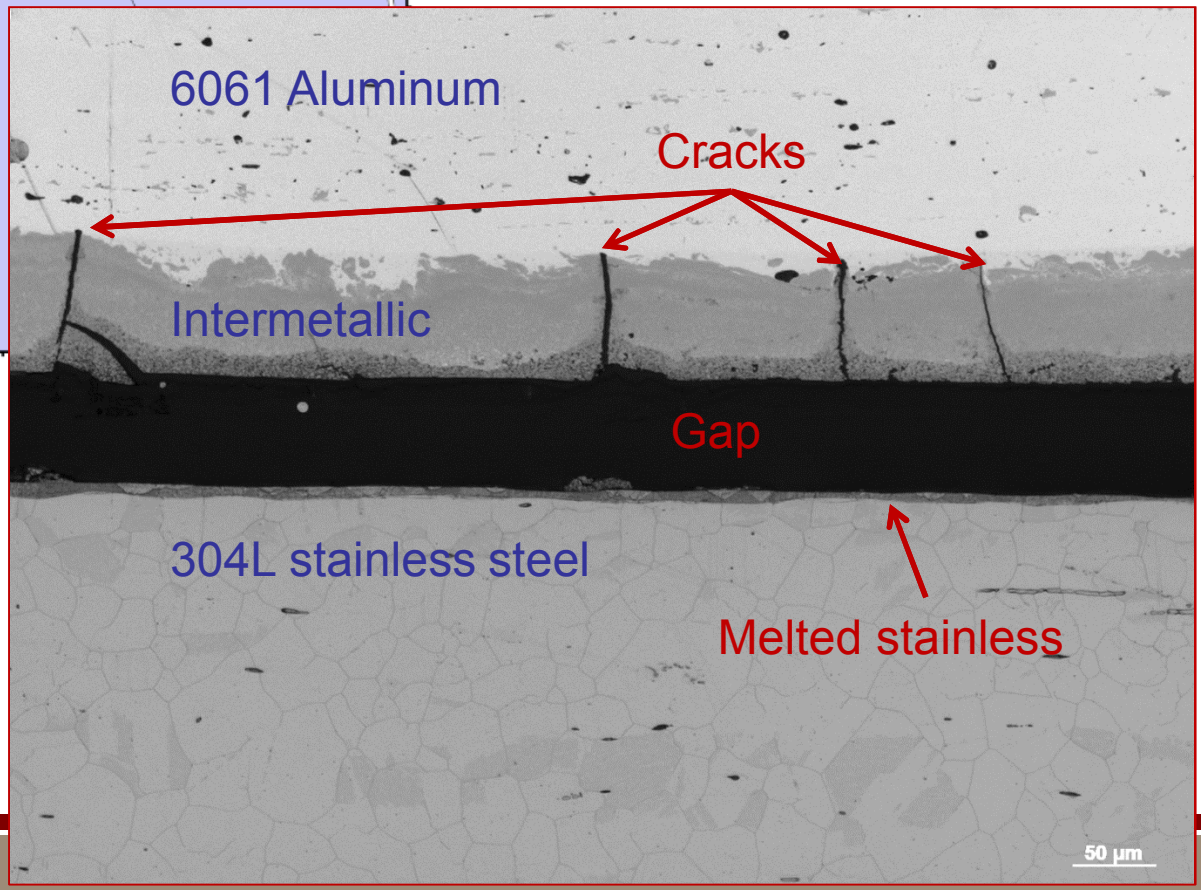


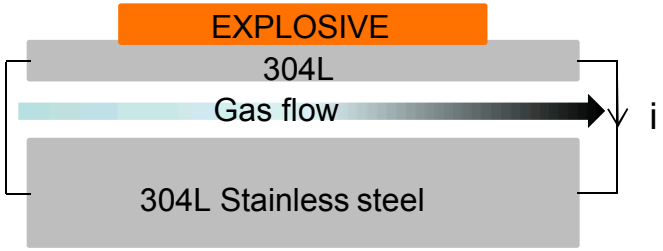


Legacy valve design



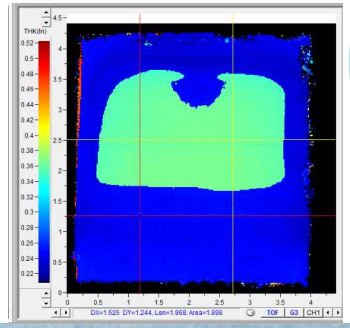






Testing and analysis

- 130 tests
- Variables
  - Flyer plate thickness
  - Angle
  - Velocity



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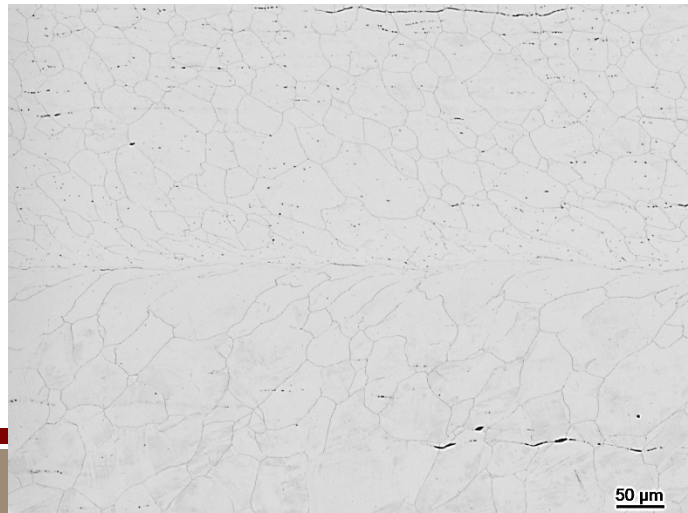

Ultrasonic analysis

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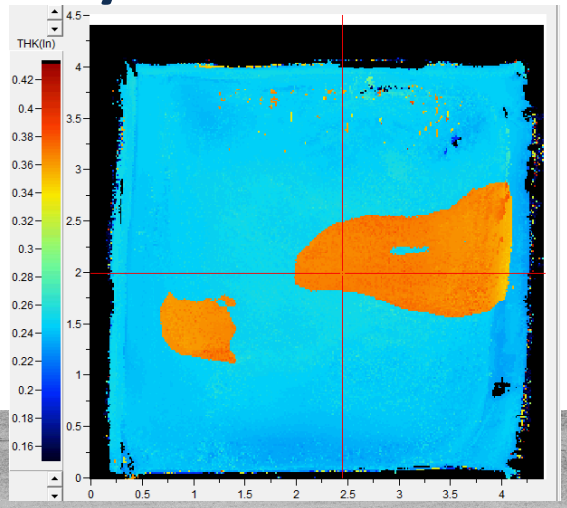
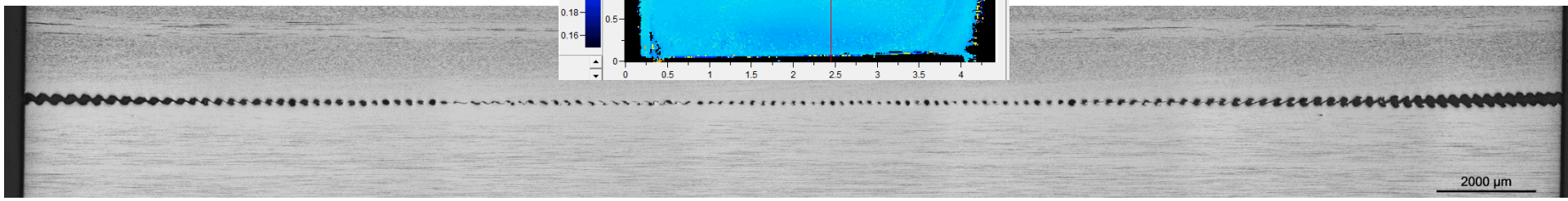
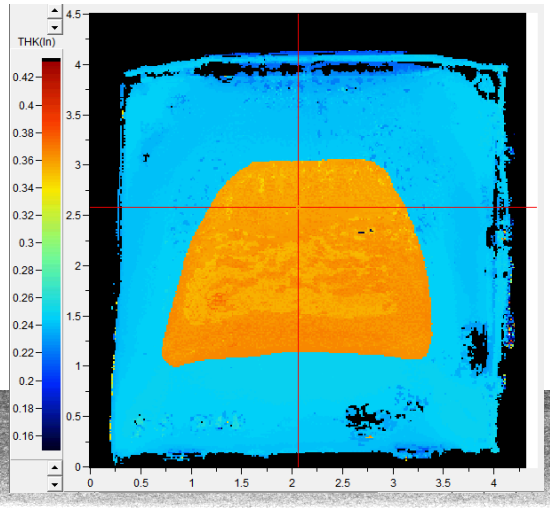
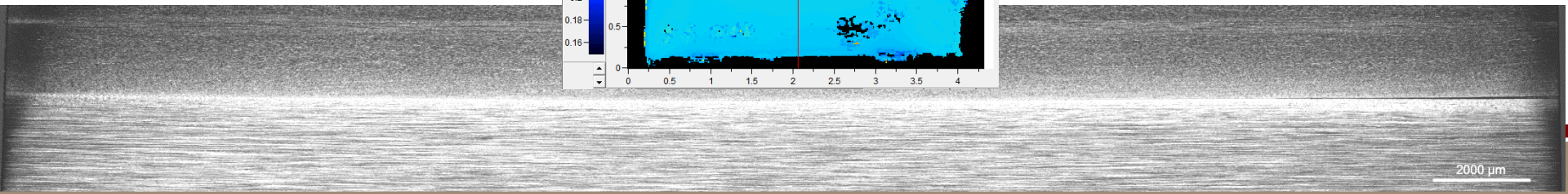
Bonded vs. Un-bonded





Cannot infer weld quality



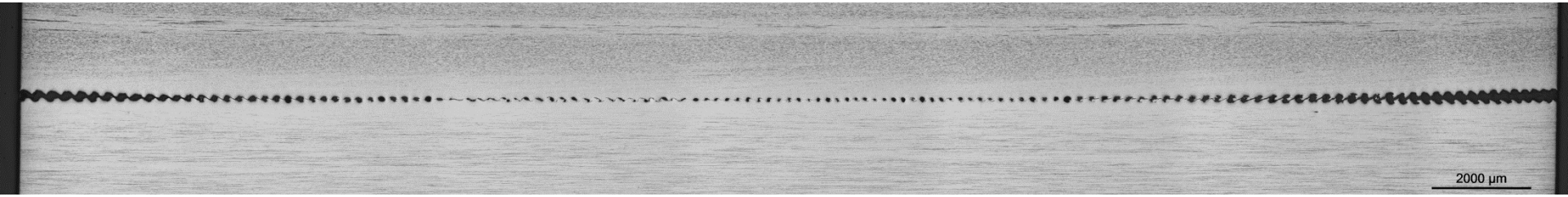


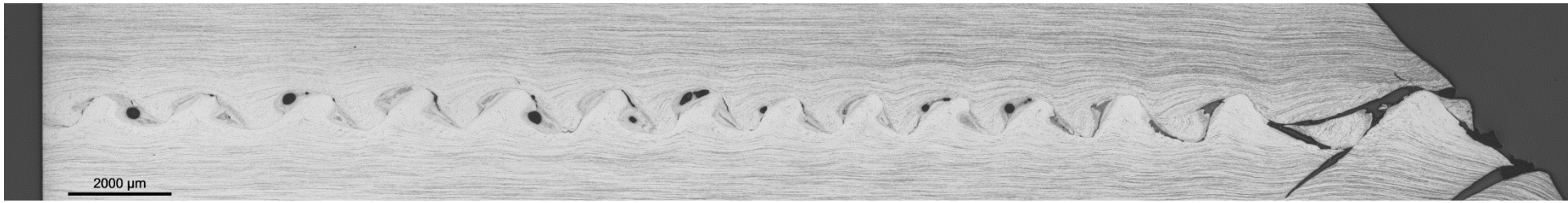
Good bond characteristics

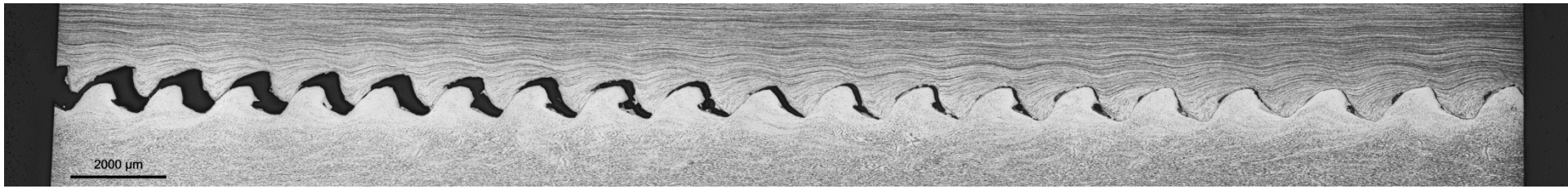
- Bond length/area
- Lack of porosity/cracking
- Minimal melting
- Recrystallization

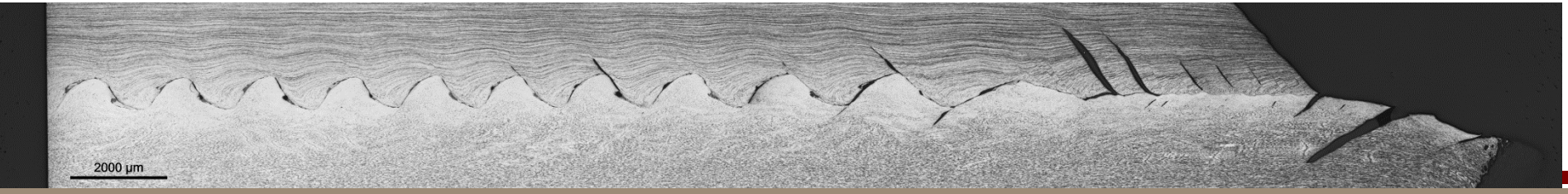
Recrystallization and melting

Less than ideal bonds









Shear bands in 304L?

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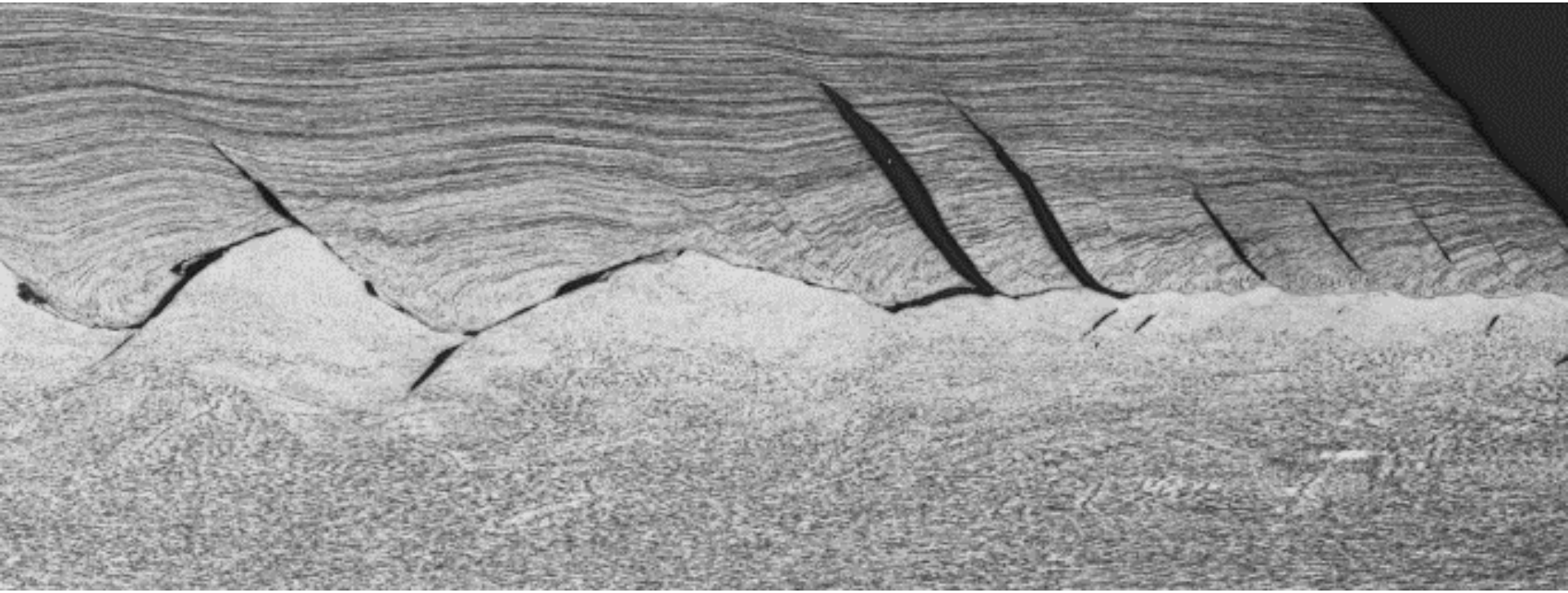
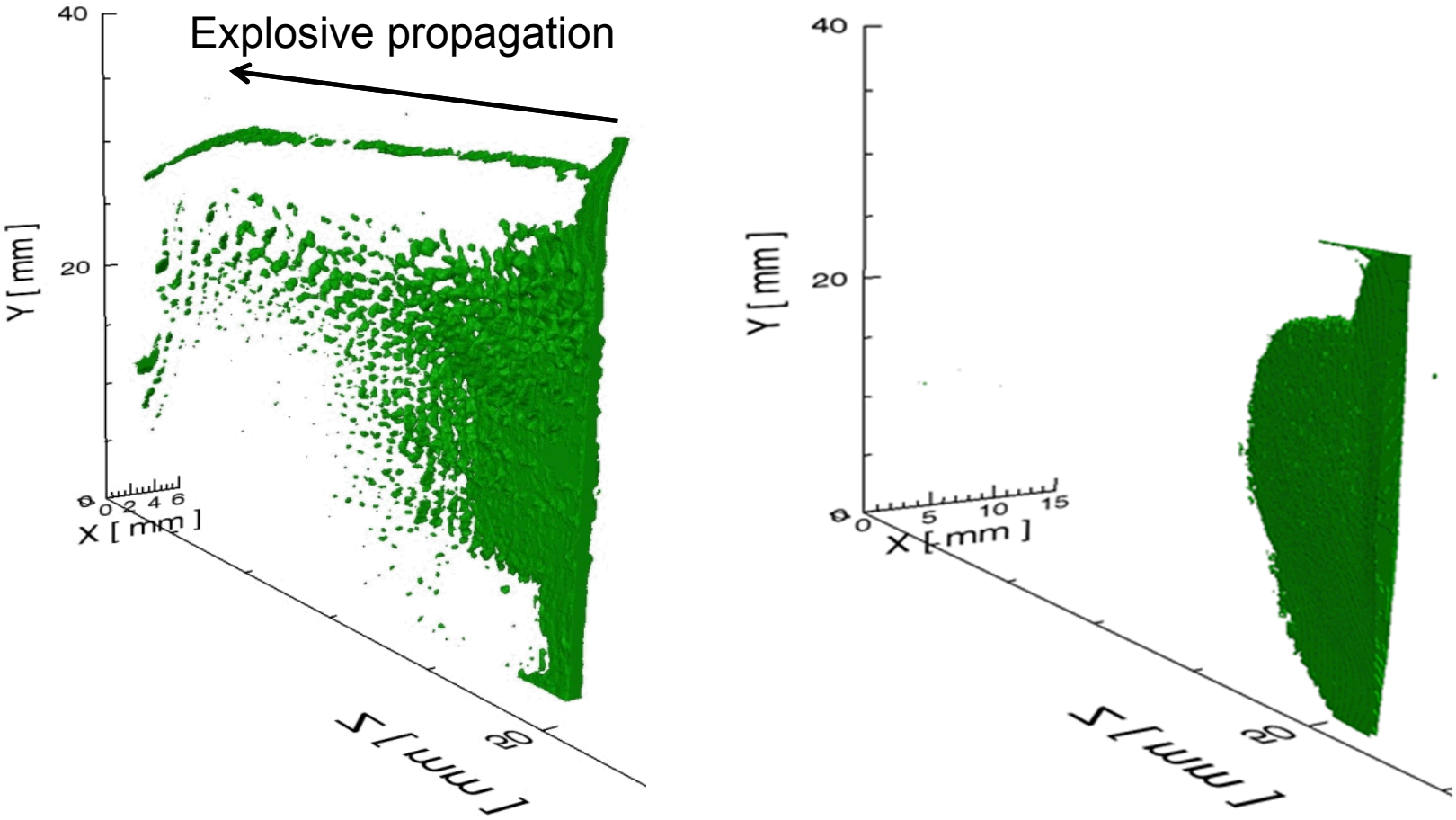
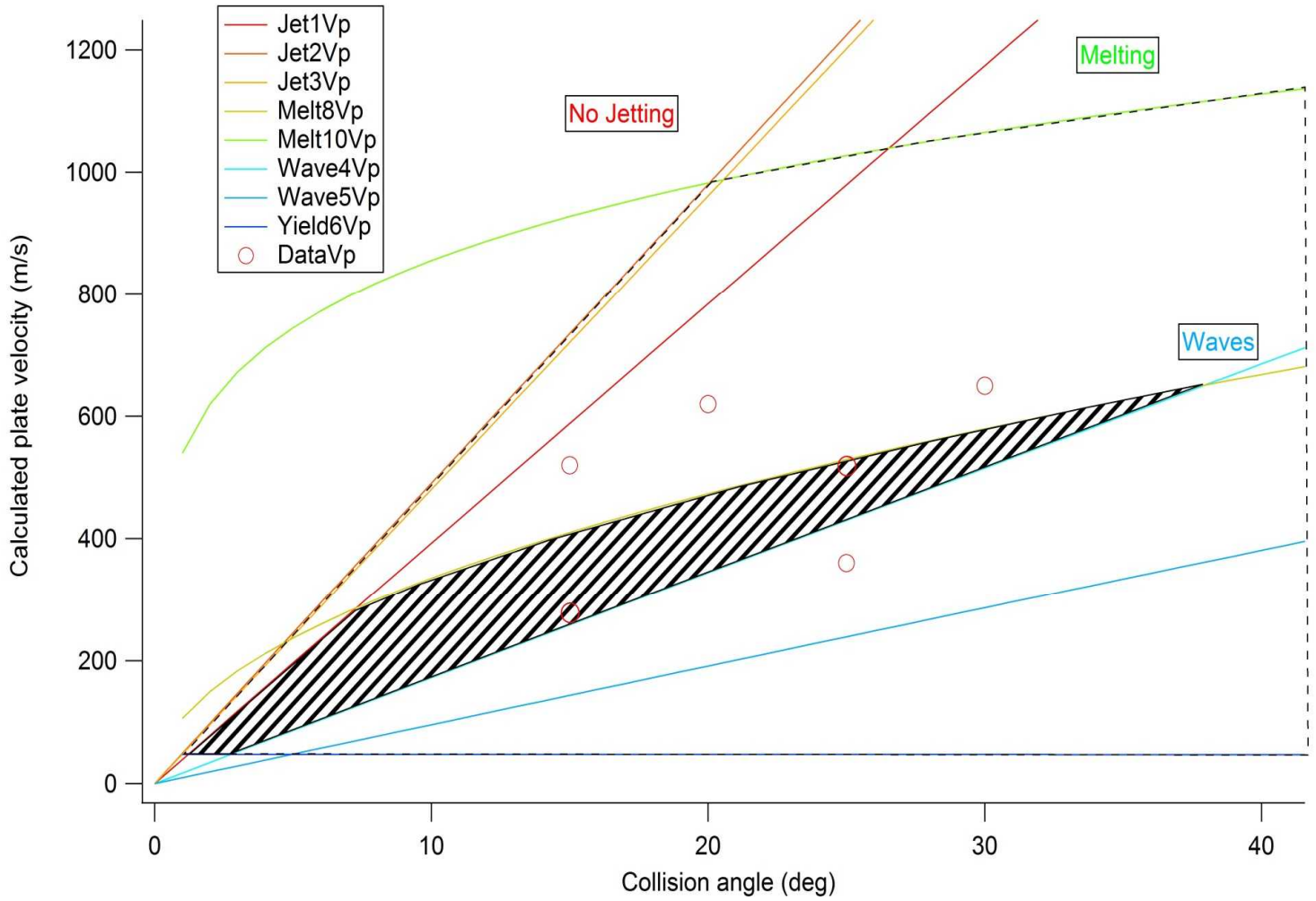


X-ray computed microtomography

- 41.5 µm per voxel edge
- Green = lack of fusion/porosity

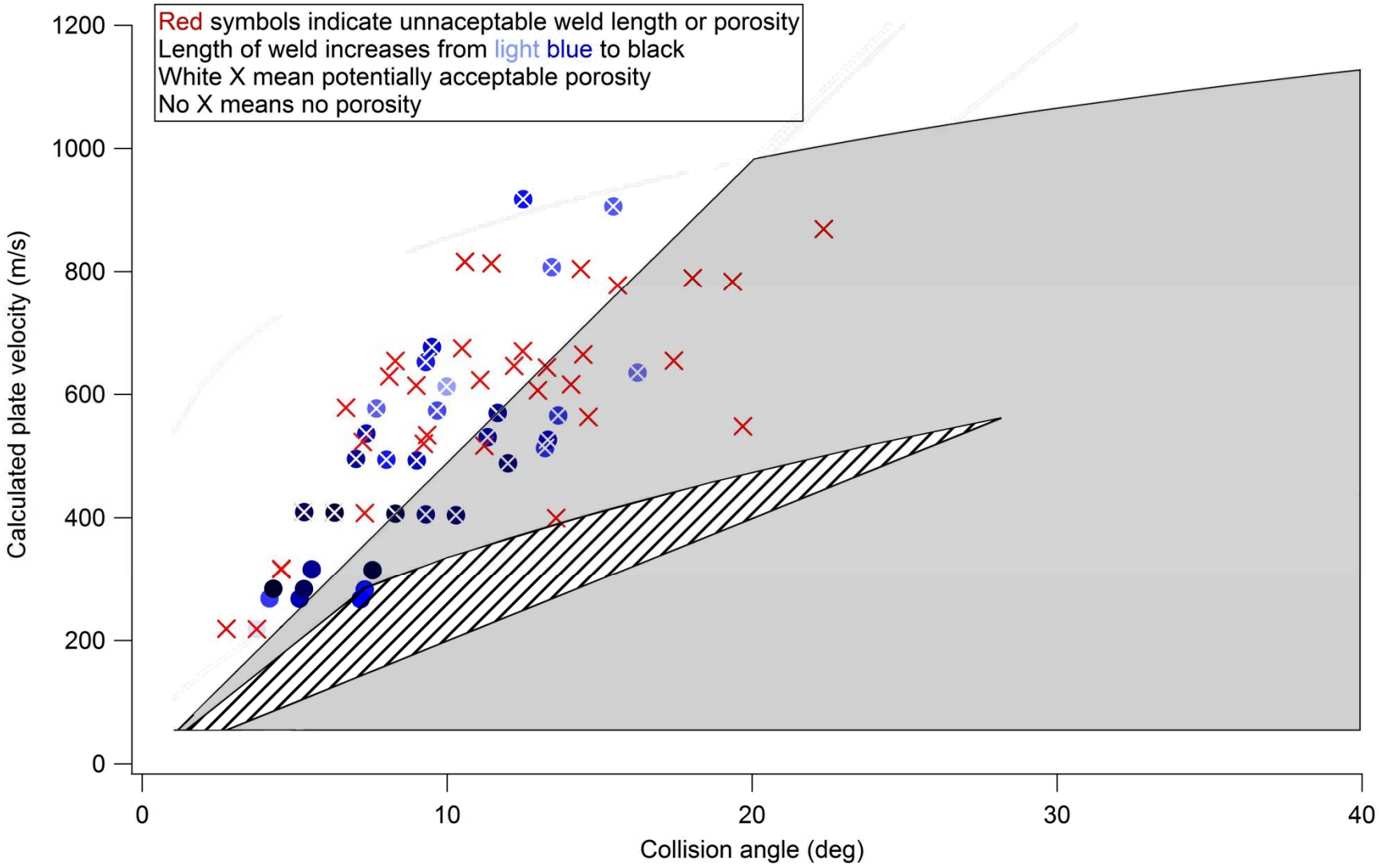


Calculated explosive weld window 304L to 304L

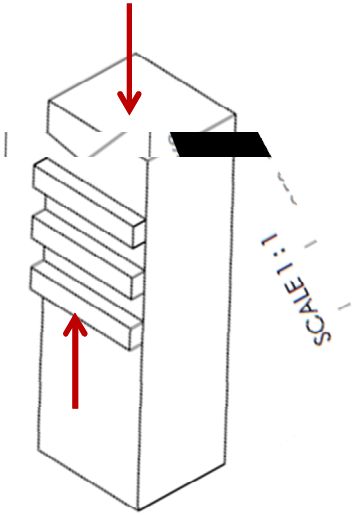


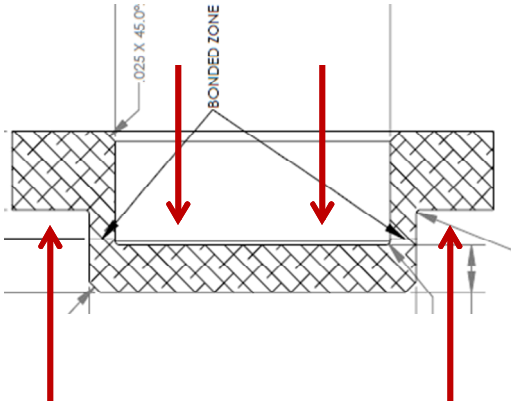
Ribeiro, J., R. Mendes, and A. Loureiro, *Review of the weldability window concept and equations for explosive welding.* Journal of Physics: Conference Series, 2014. **500**(5): p. 052038.

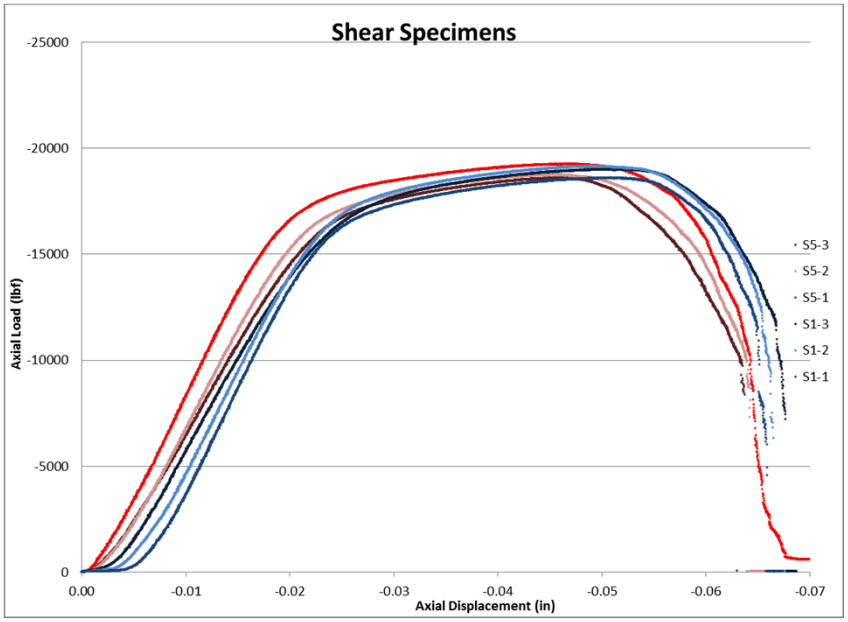
Results of explosive bonding tests

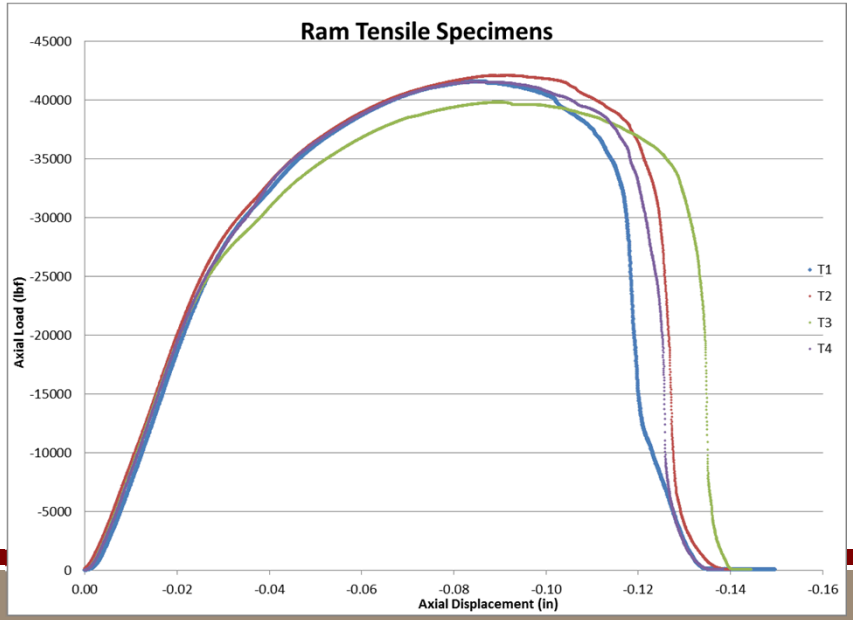


Mechanical testing









Conclusions

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- Ultrasound can determine quantity of bonded material, but not quality of bond.
- Low speed, low collision angle conditions are optimal for bonding.
- Literature welding parameter windows do not capture all explosive conditions.

Continuing work

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- Transfer flat-plate work to cylindrical design
- Mechanical testing of interfaces
- Analysis of μCT for connectedness of pores