

# ICHSF 2018

INTERNATIONAL CONFERENCE  
ON HIGH SPEED FORMING



**THE OHIO STATE  
UNIVERSITY**  
COLLEGE OF ENGINEERING



武漢理工大學



## Welding of 2024-7075 Aluminum Alloys and 5A06 Aluminum to Stainless Steel 321 by Vaporizing Foil Actuator

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Chen, G.S. Daehn

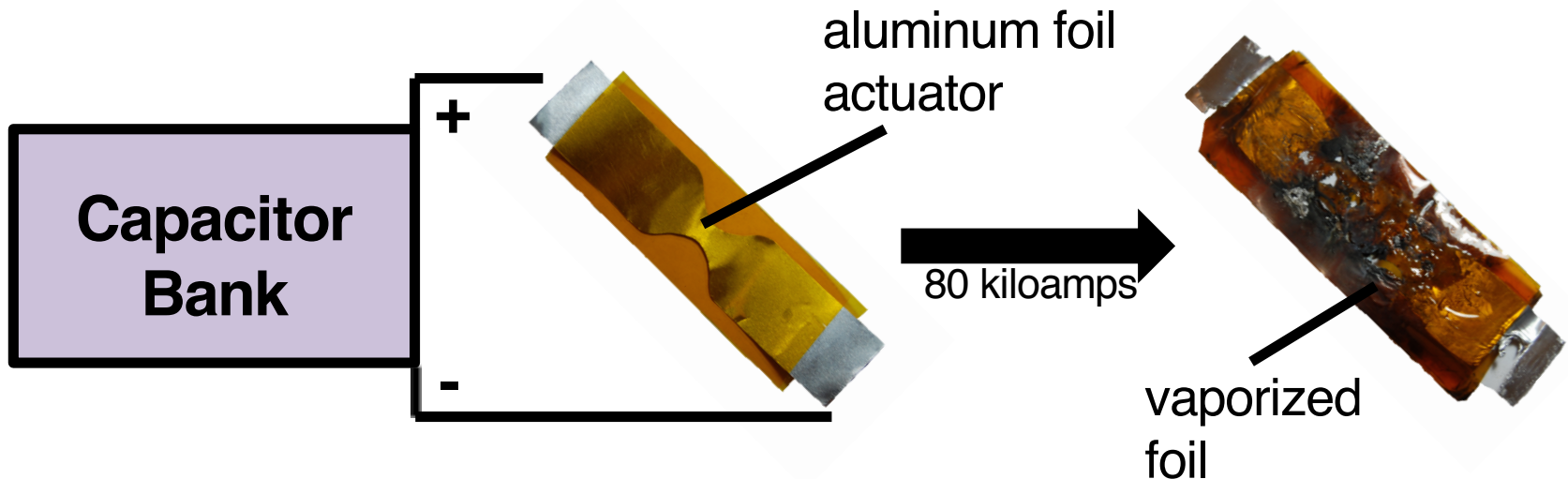
# Outline

- Introduction: Vaporizing Foil Actuator Welding (VFAW)
- VFAW of 2027 and 7075 aluminum alloys
- VFAW of 5A06 aluminum to stainless steel 321

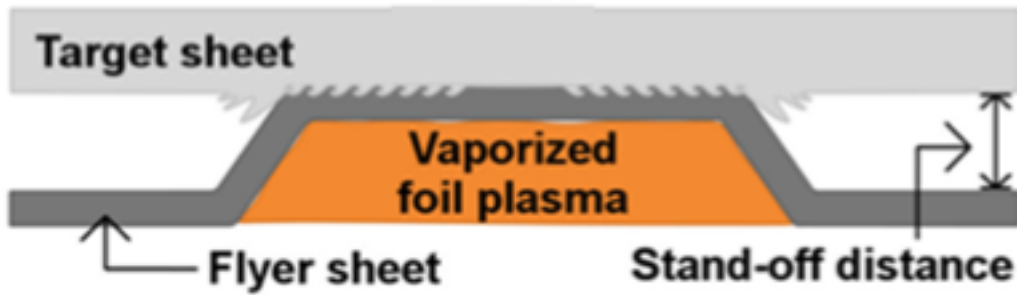


# Vaporizing foil actuator welding (VFAW)

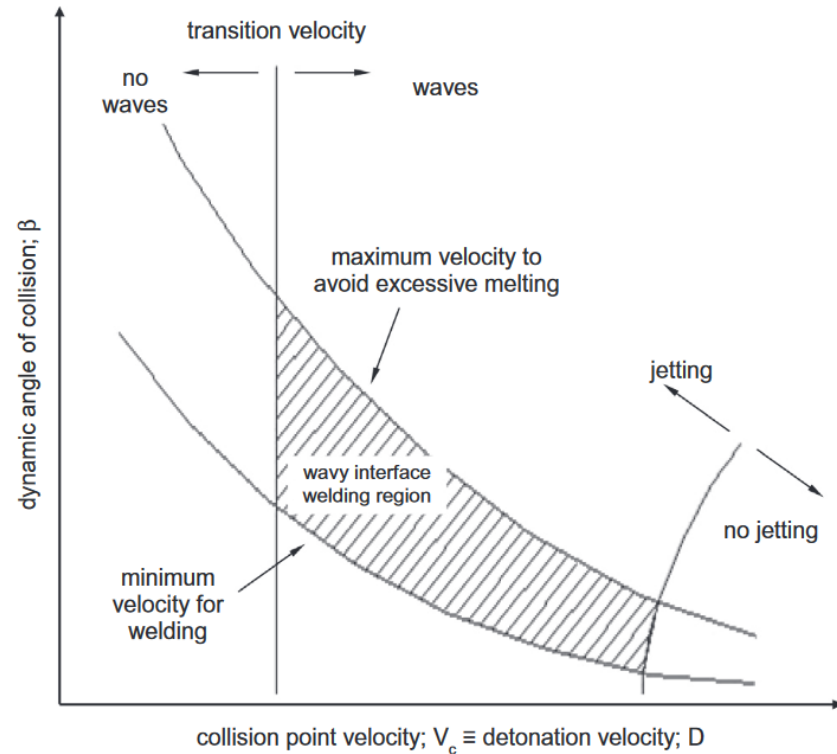
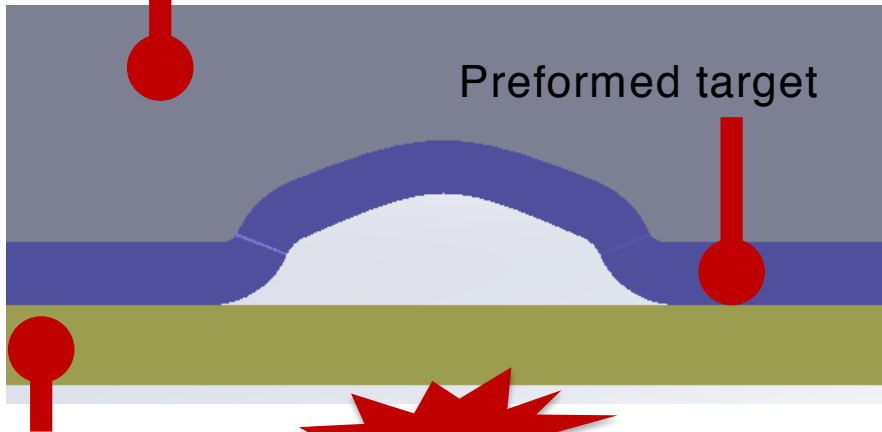
- An impact welding process: to create metallurgical bond by high-speed oblique impact.
- Explosive welding: explosives; MPW: magnetic force; VFAW: vaporization of the foil.
- Joint of lap geometry with thickness in mm.



# VFAW setup



Preforming die



Flyer sheet



# Advantages of VFAW

- No heat affected zone
- High energy efficiency
- Capable of high impact velocity
- Smaller scale than explosive welding
- No longevity issue or conductivity requirement



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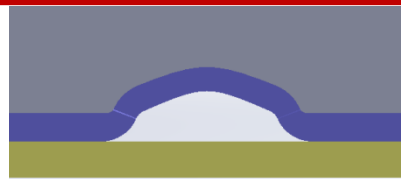
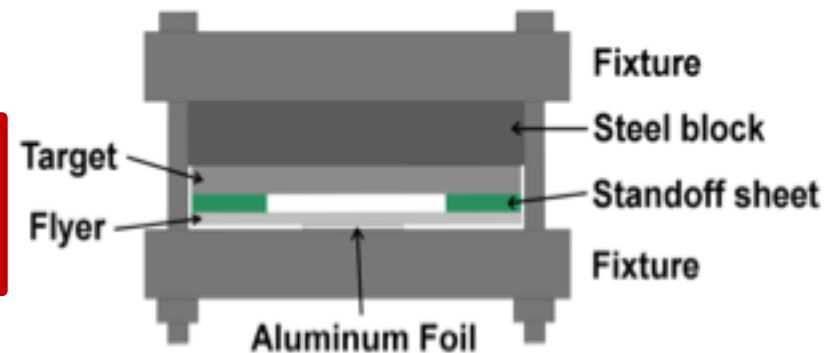
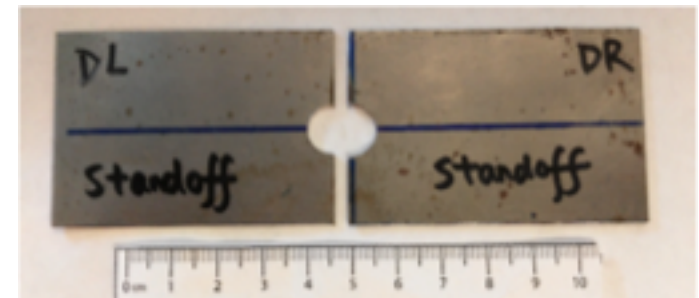
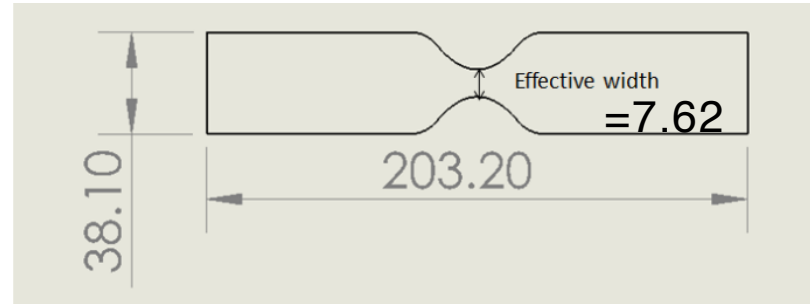
# Motivation

- Weight reduction of vehicles and aircrafts for energy saving is strongly desired.
- Although widely employed in aerospace applications, both 2XXX and 7XXX series alloys show limited weldability.
- To present a new benchmark method in comparison with friction stir welding.



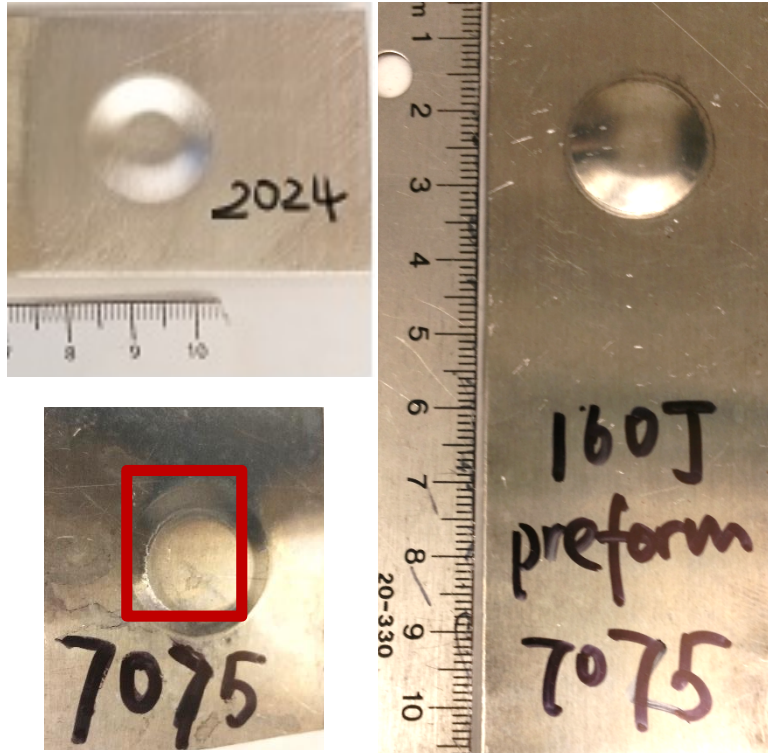
# Approach

- VFA spot welding at 4.8 kJ; spot size = 11-mm diameter.
- 1.3 mm thick AA7075-T6 and 1.6 mm AA2024-T3
- 3 different ways to create the distance for flyer to accelerate
  - A. Steel half standoff sheets and 2024-T3 as the flyer
  - B. Preformed 2024-T3 sheet as the target
  - C. Preformed 7075-T6 sheet as the target

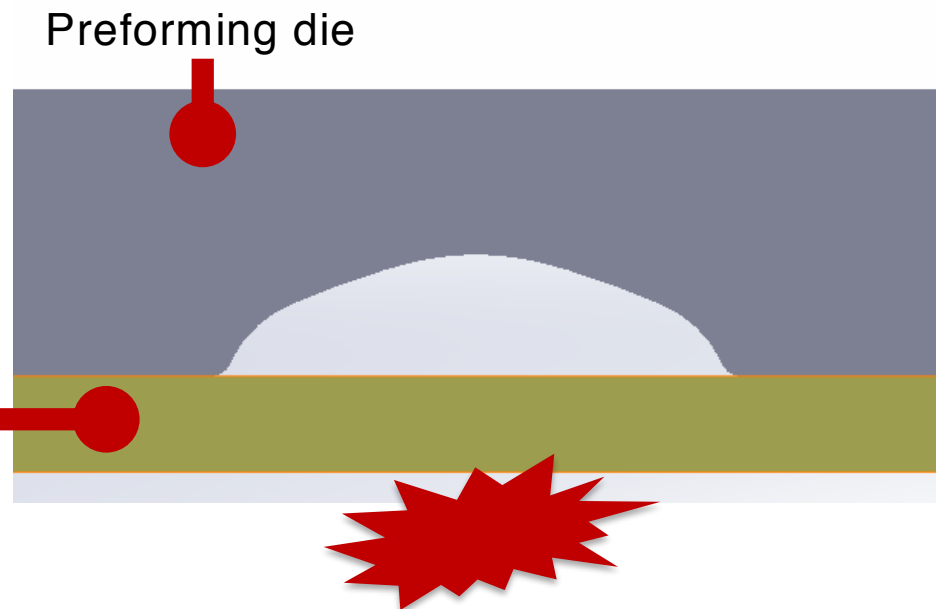




# VFA dynamic forming of 7075-T6



- 7075-T6 was formed by vaporizing foil actuator at an input energy of 160J
- No cracking by dynamic forming
- Punch is not required for forming



Target sheet to be preformed



# Results: mechanical test



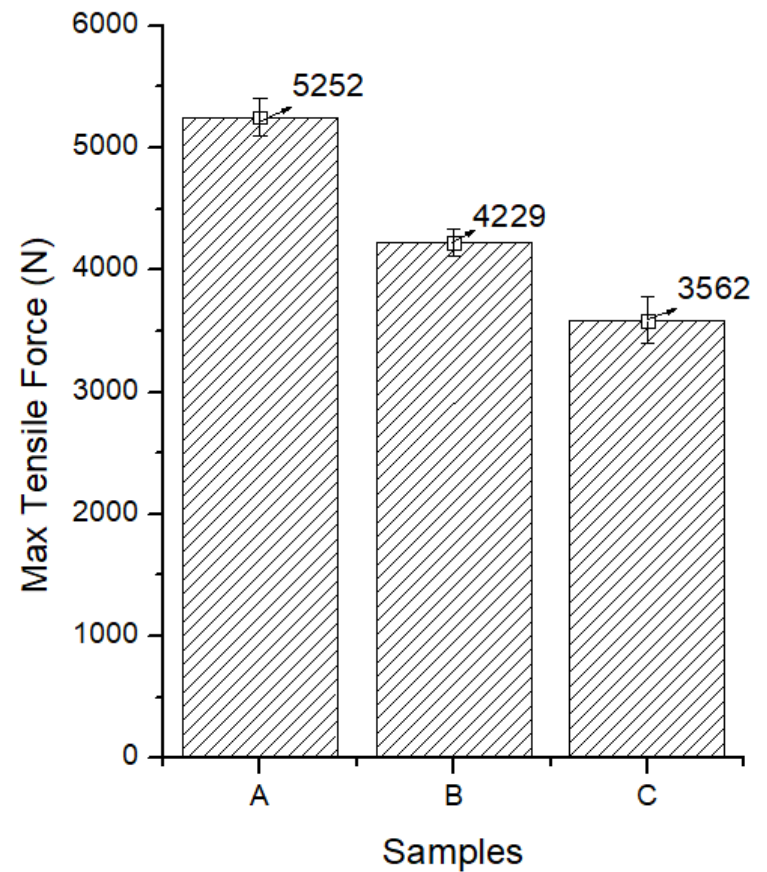
A: Pull-out failure



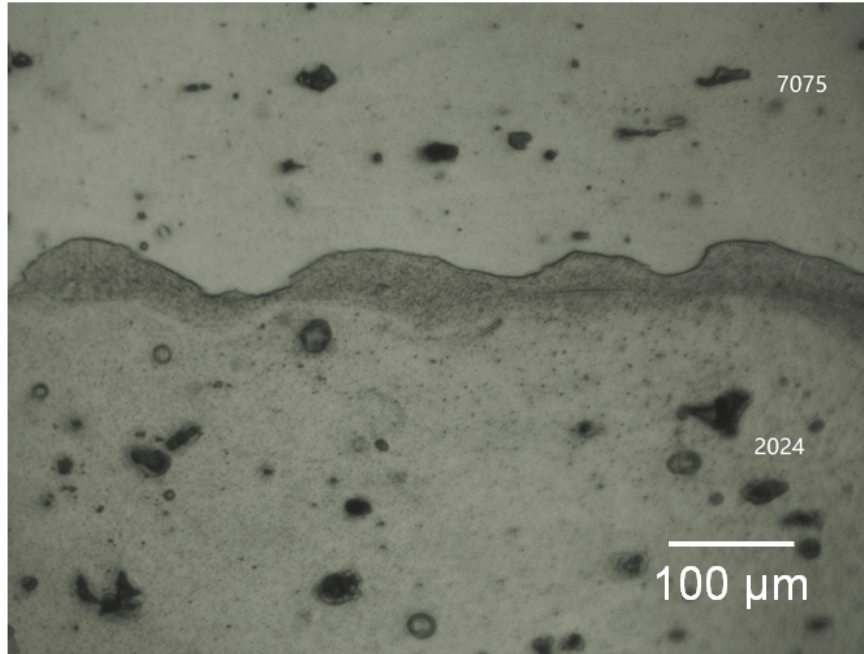
B: Interfacial failure



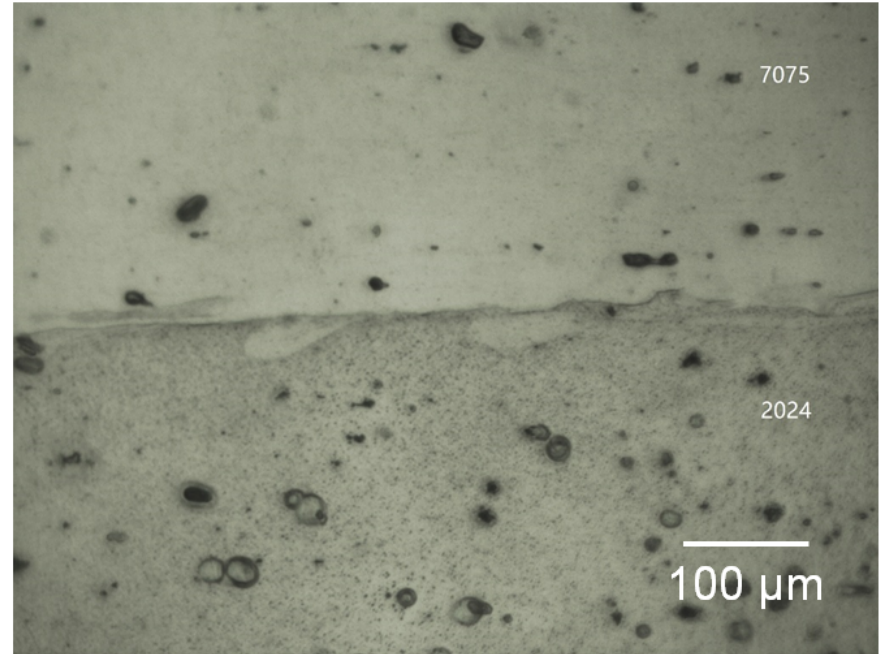
C: Interfacial failure



# Results: microstructure



B (7075 as the flyer)



C (2024 as the flyer)

- Sample B has greater waviness than C
- Work hardened 7075 is less likely to form pronounced waves.



# Conclusion

- Vaporizing foil actuator welding offers a feasible method to weld 2024/7075 aluminium alloy pairs.
- Strengths of the welds made with standoff sheets is higher than those of the ones made with preformed target sheet.
- VFA dynamic preforming is one solution for forming materials with poor formability.

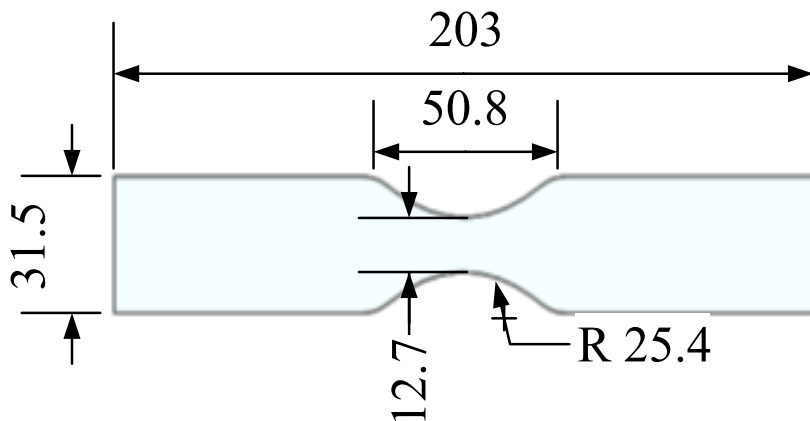
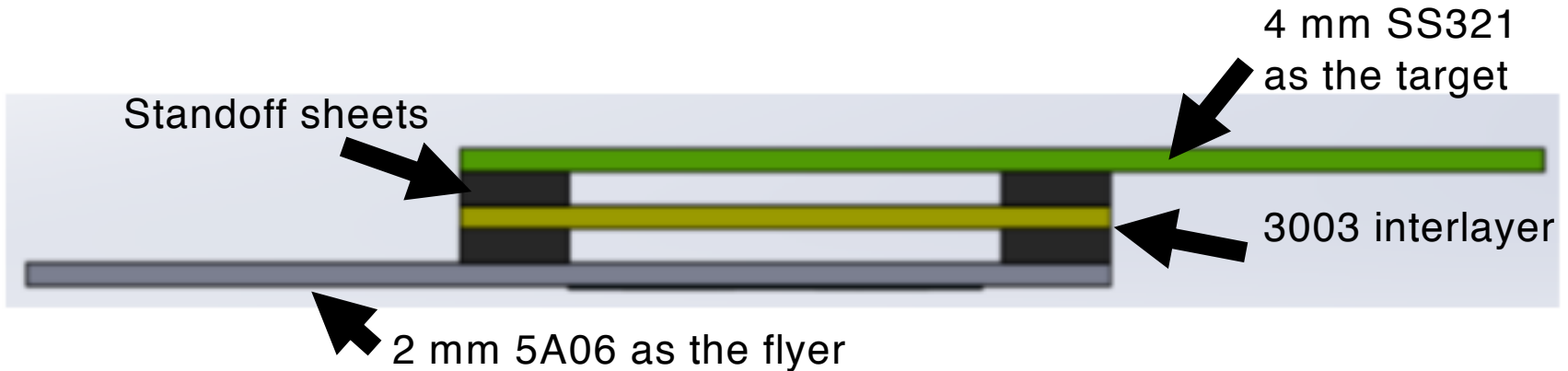


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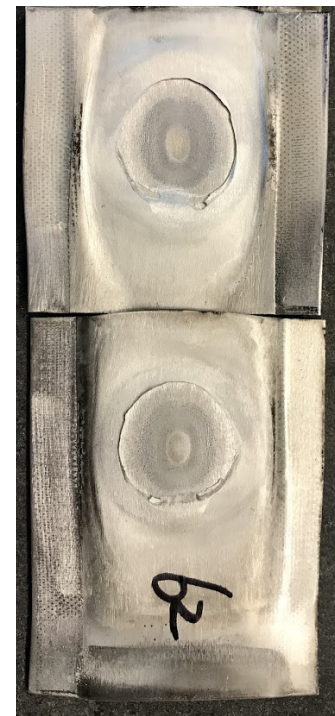
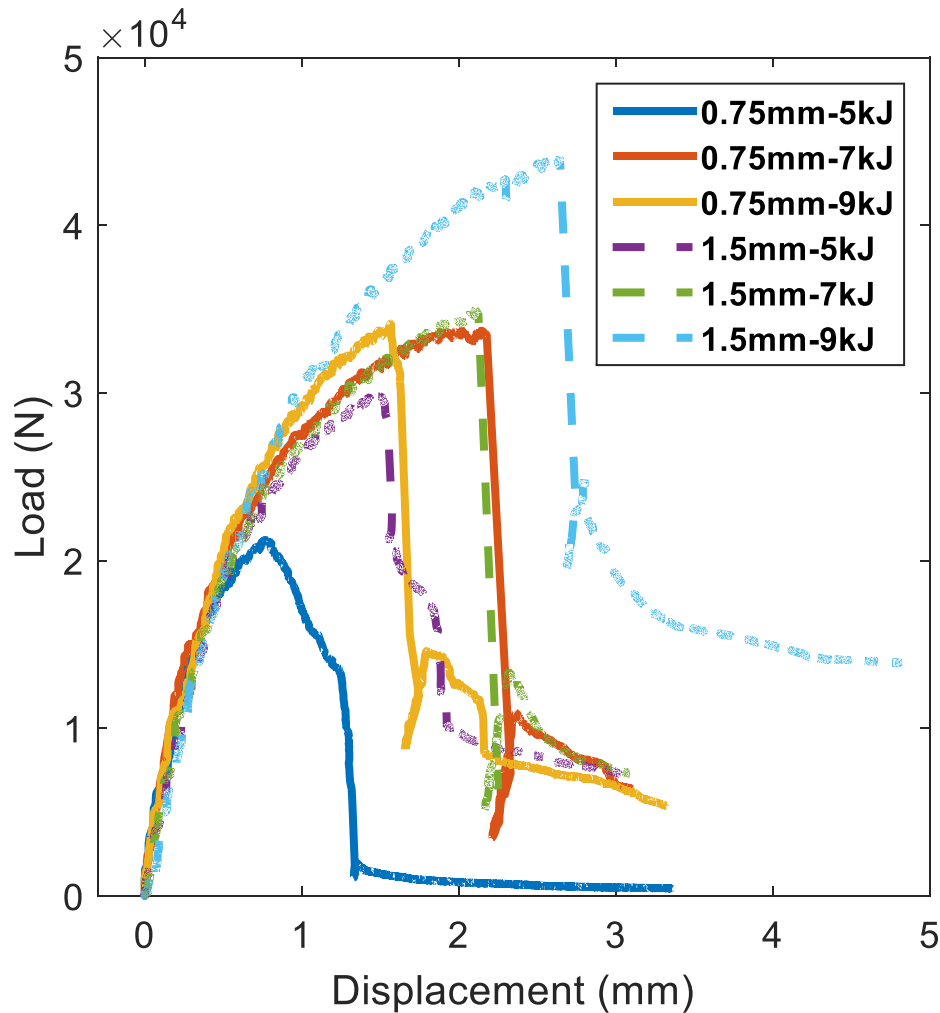
# Approach



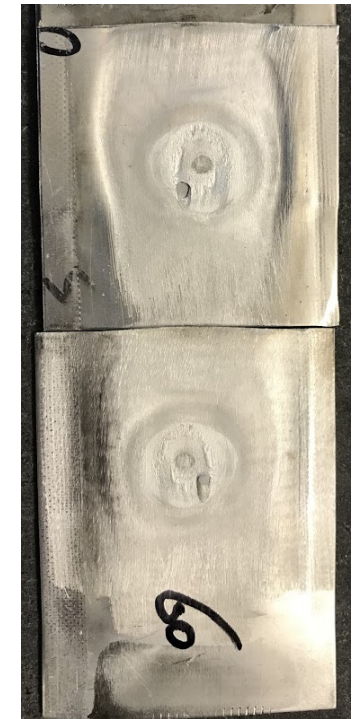
- 1 mm thick Al 3003 was used as the interlayer.
- The distance between the interlayer and flyer was set to be 3 mm.
- The distance between the interlayer and target was tested at 0.75 mm and 1.5 mm
- Energy input at 5 kJ, 7 kJ and 9 kJ



# Results: lap shear tensile test



0.75 mm-9kJ

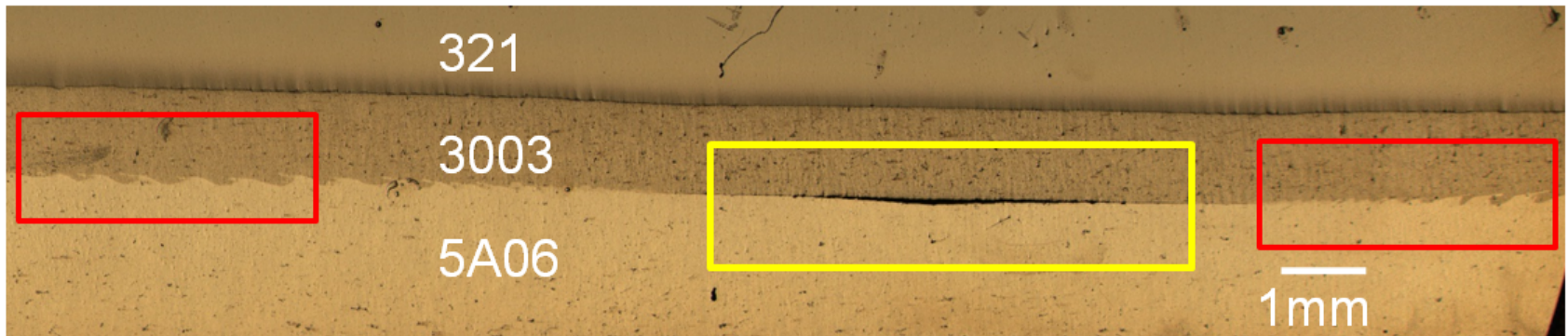


1.5 mm-9kJ



# Results: 5A06-3003 interface

9 kJ at 0.75mm gap between interlayer and target



9 kJ at 1.5mm gap between interlayer and target





# Results: Al3003-SS321 interface

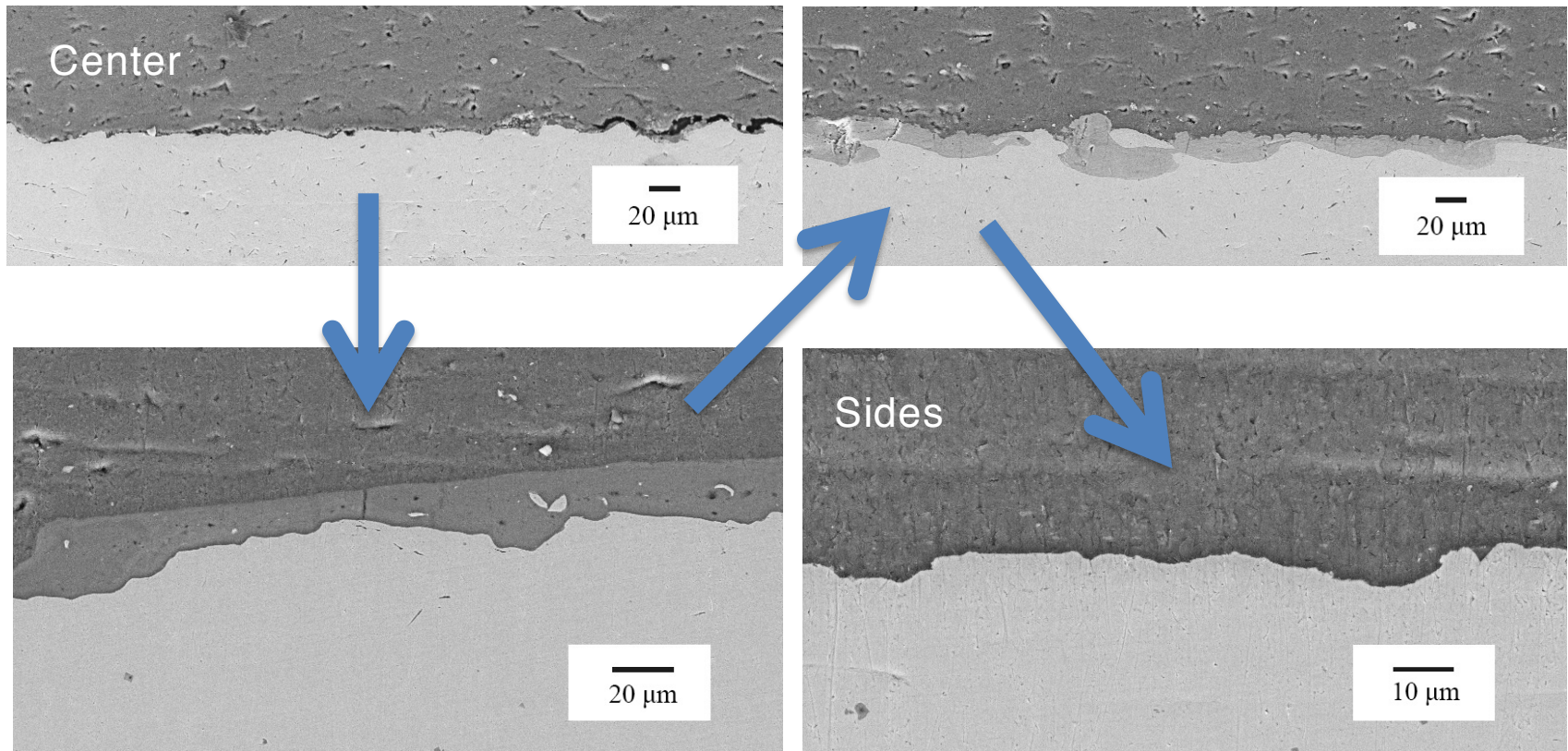
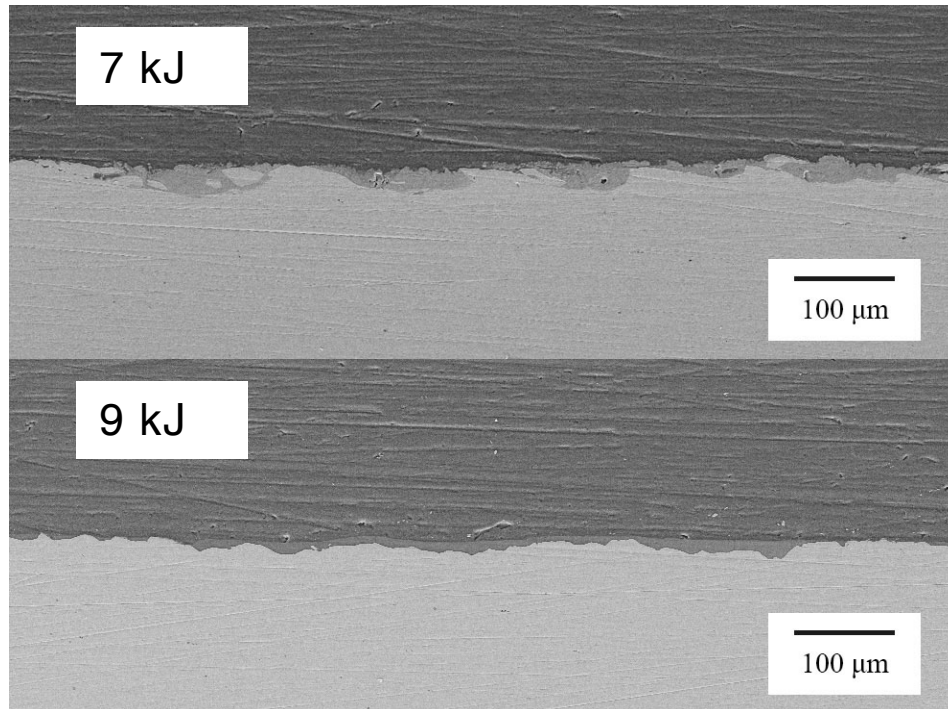


Figure: Weld made at 5 kJ with 1.5 mm between the interlayer and target

# Results: Al3003-SS321 interface



- Intermetallic compounds (IMC) was thinner but more continuous with increasing input energy



# Conclusion

- VFAW using interlayer is valid for welding of 5A06 to SS321. Peak load of 44 kN was obtained from 2 mm 5A06.
- For 3003-5A06 joining interface, the waviness increases and unwelded area decreases as distance between the interlayer and target increases.
- Processing parameters including standoff distance between the interlayer and target and the and input energy have effects on the microstructure and mechanical response of the weld.
- Larger standoff distance and higher input energy create stronger welds.



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