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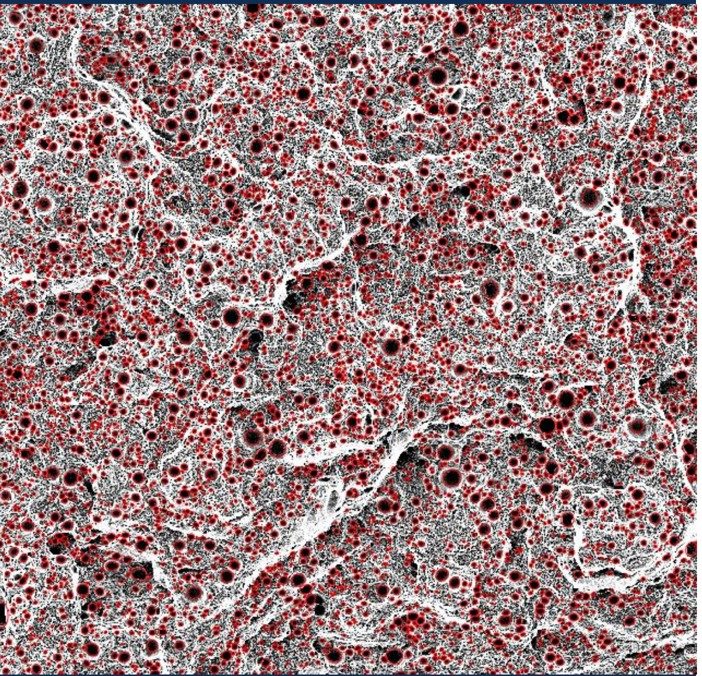

Relating Defects at the Fracture Surface to Physical Properties of AM Materials

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Sandia National Laboratories

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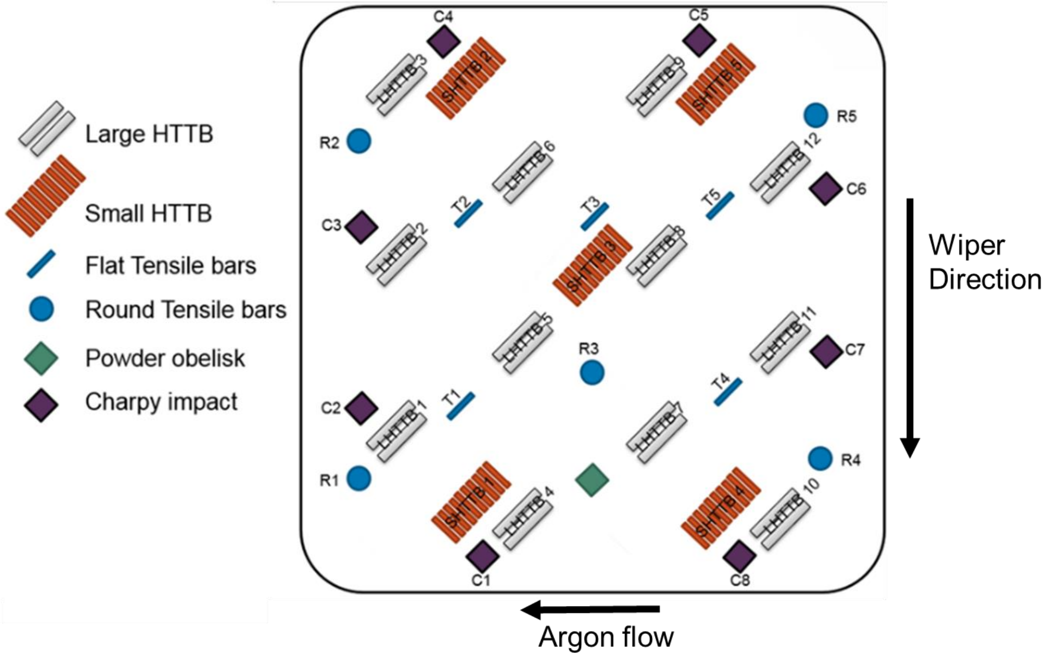
Outline

- Goal: Explore the relationship between porosity and physical properties as part of an effort to qualify AM materials
- Experimental Setup/Data Structure
- Relationship between physical properties and build plate
- Estimating void fraction from SEM images
- Relationship between porosity and physical properties

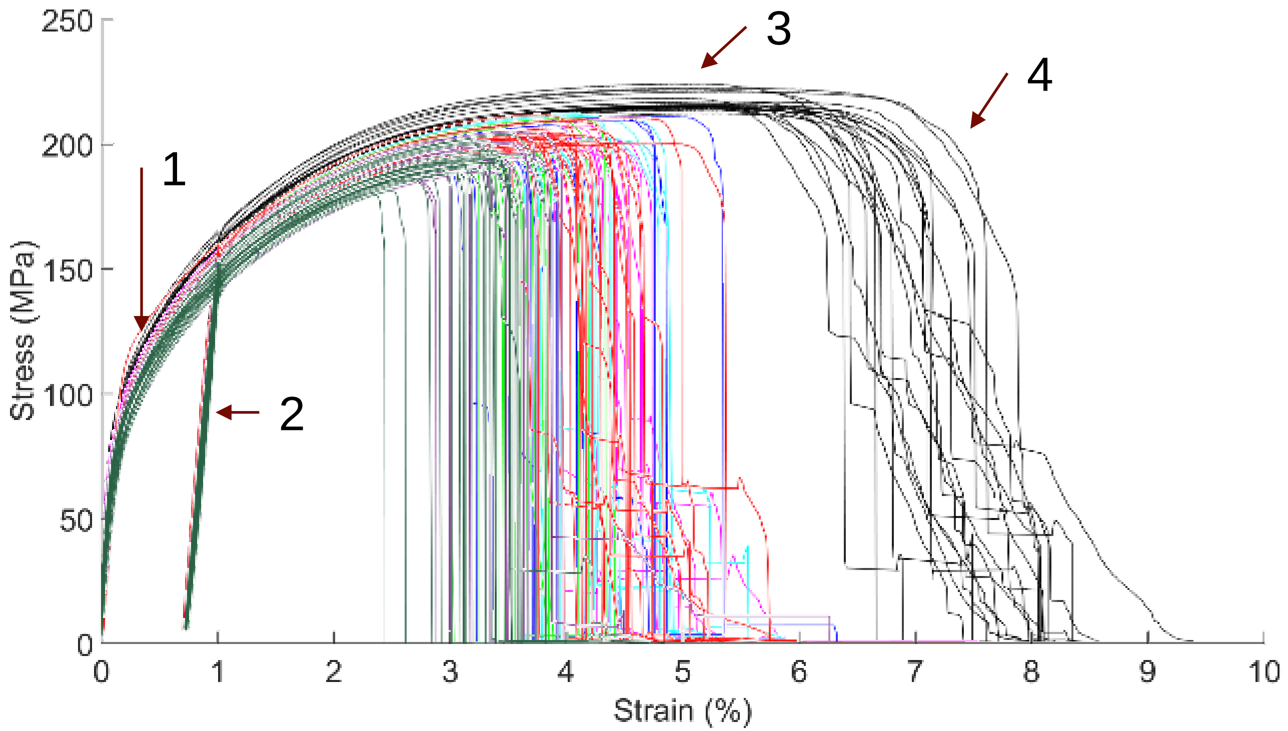
Sample Description

- $AlSi_{10}Mg$ tensile dogbone samples from 8 build plates
  - 11 locations measured on each plate
  - Powder reuse samples: builds A & F used fresh powder, others used reclaimed powder
- SEM images of the fracture surfaces collected in VPSE mode



Sample Description

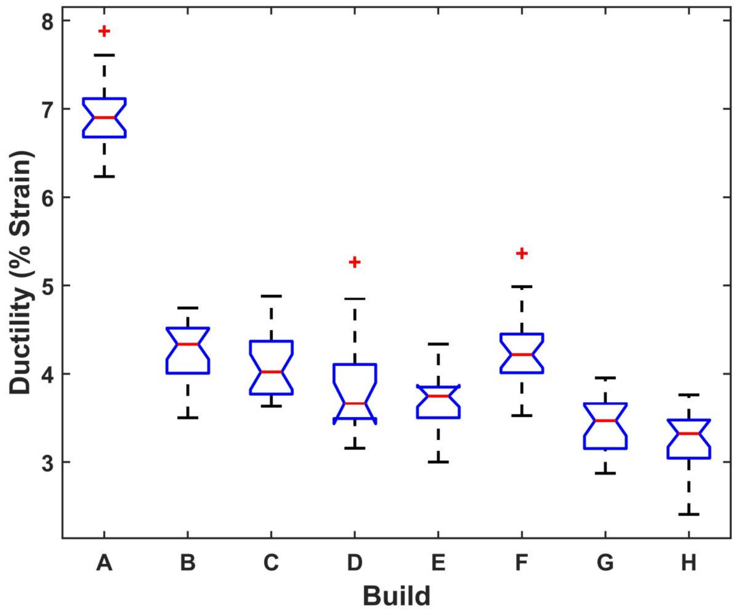
Build	Powder condition
A	Fresh
B	Reused once
C	Reused twice
D	Reused 3 times
E	Reused 4 times
F	Fresh
G	Reused once
H	Reused twice

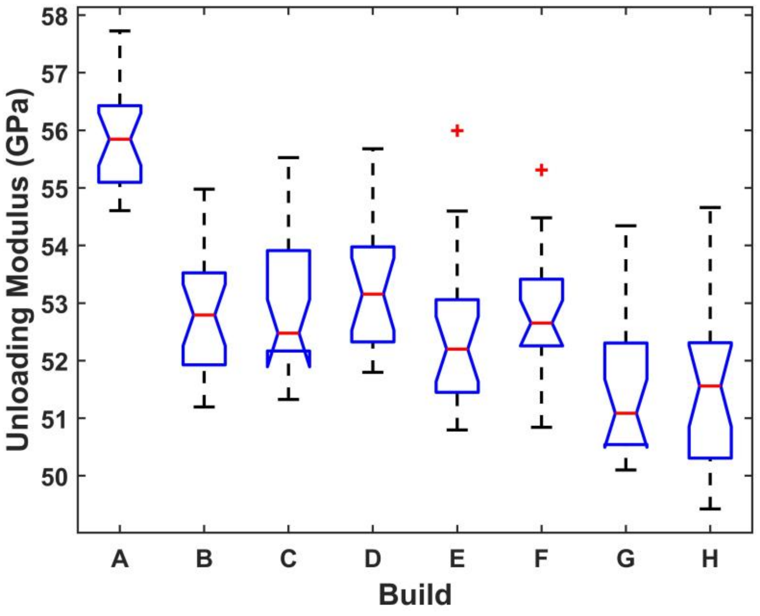


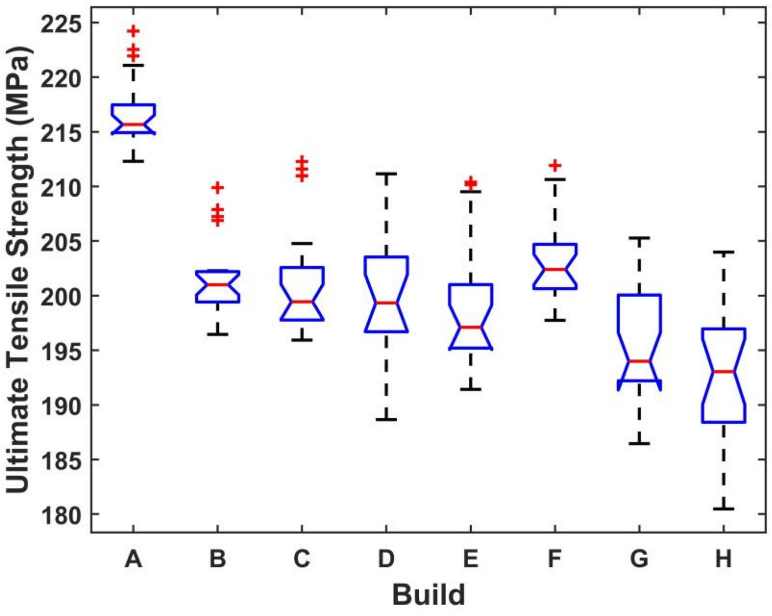
1. Yield Stress
2. Unloading Modulus
3. Ultimate Tensile Strength
4. Ductility

Properties By Location/Stress Strain Curves

- Physical properties vary with build/powder status
- Build A is much better than Build H

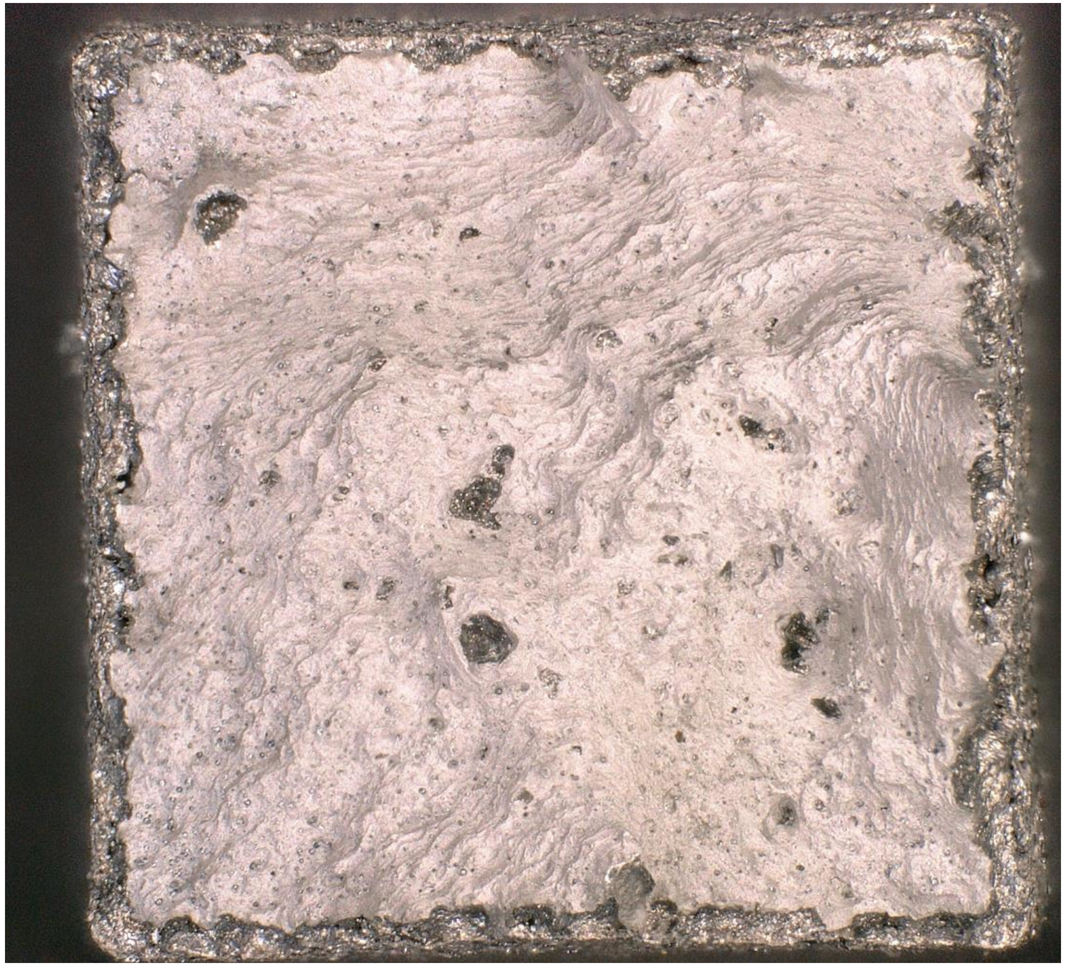




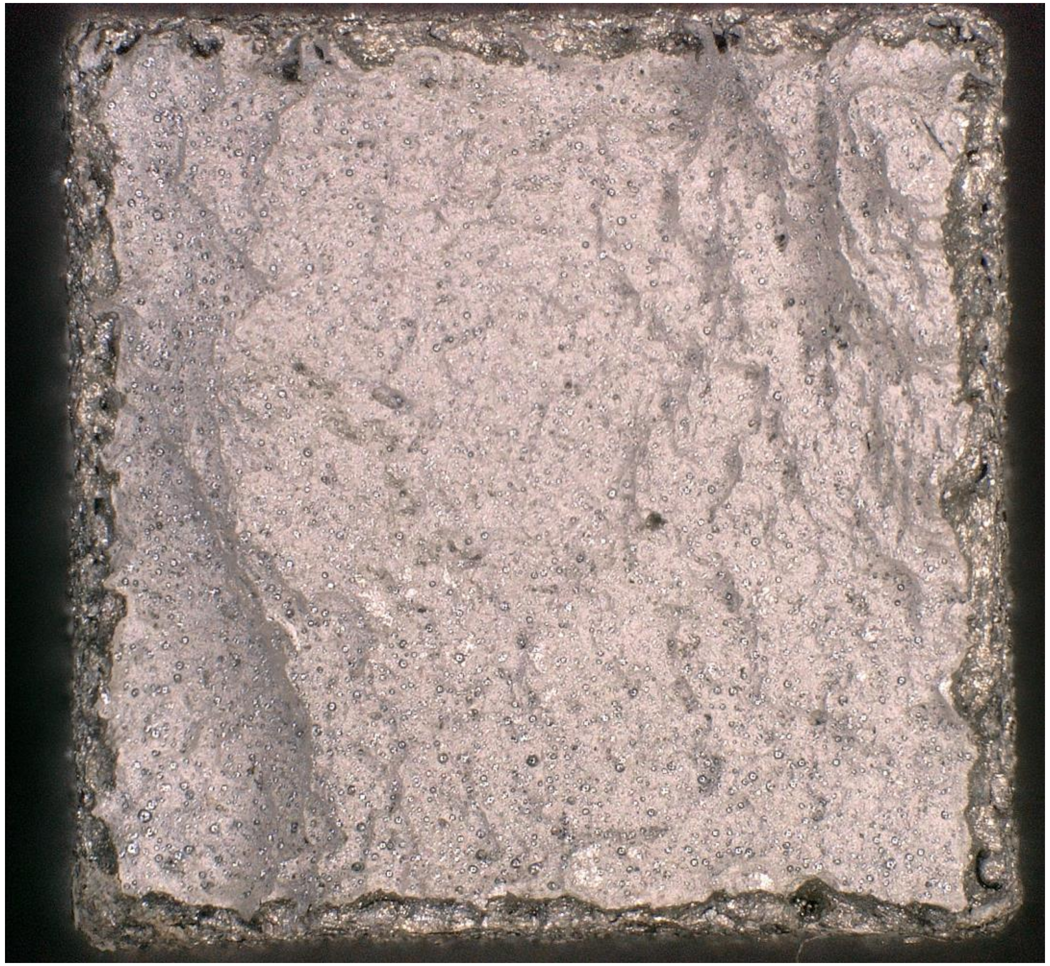


Keyence Images of Porosity

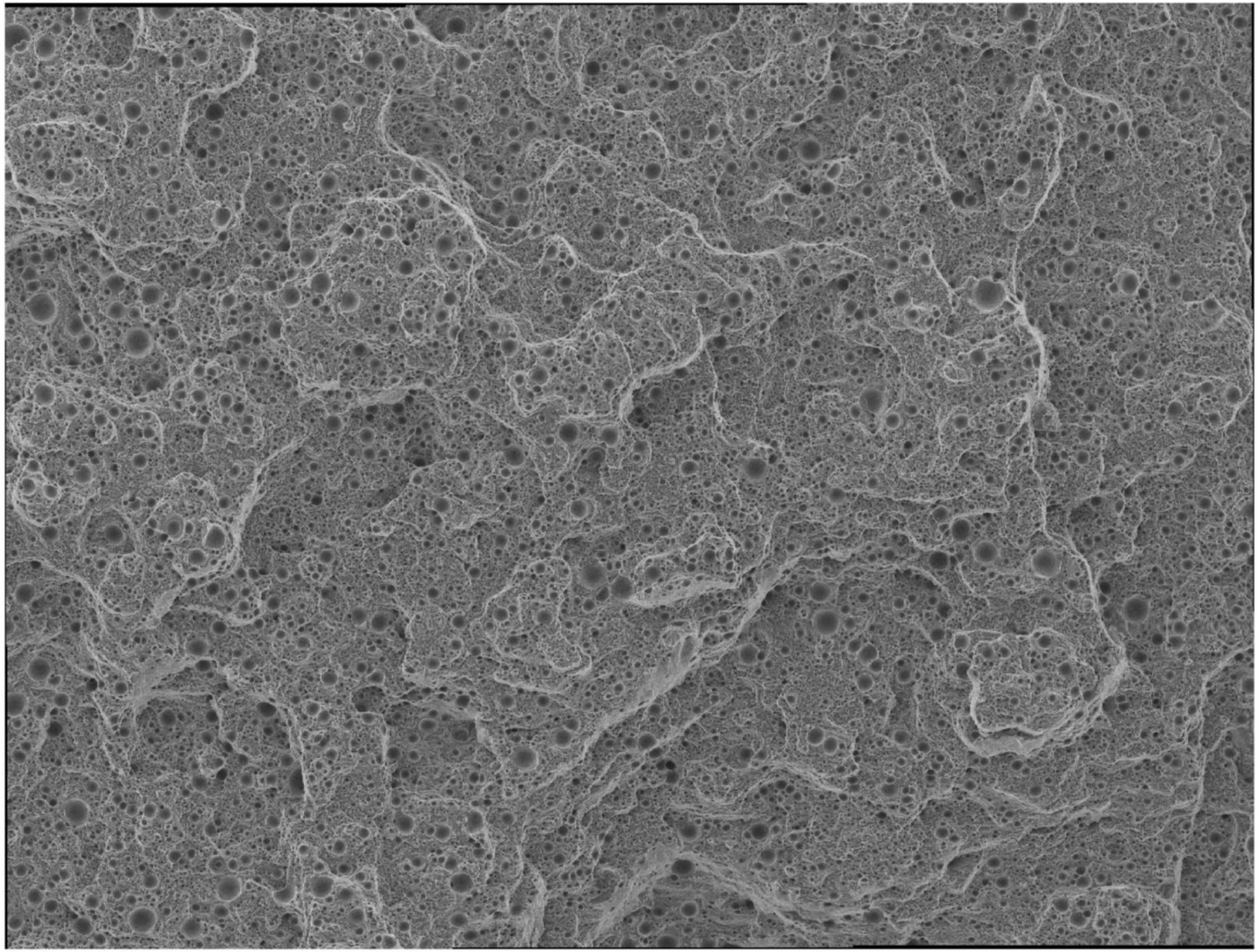
Build A



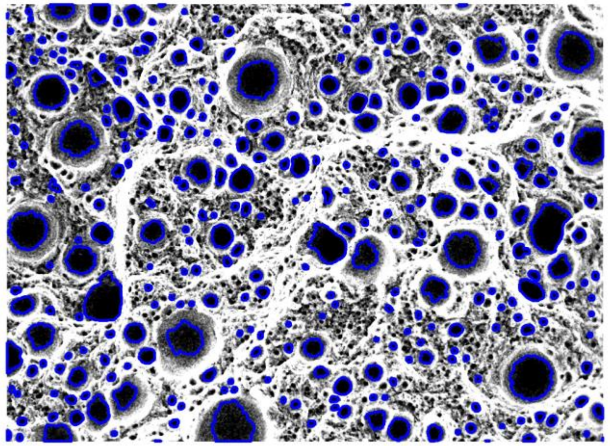
Build H



SEM Images of Fracture Surface

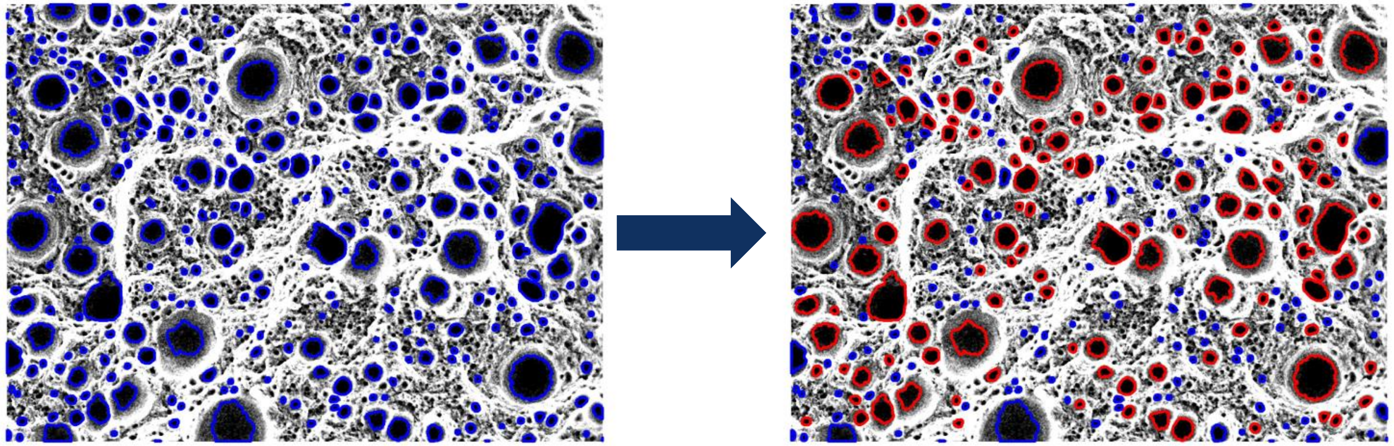


Void Detection



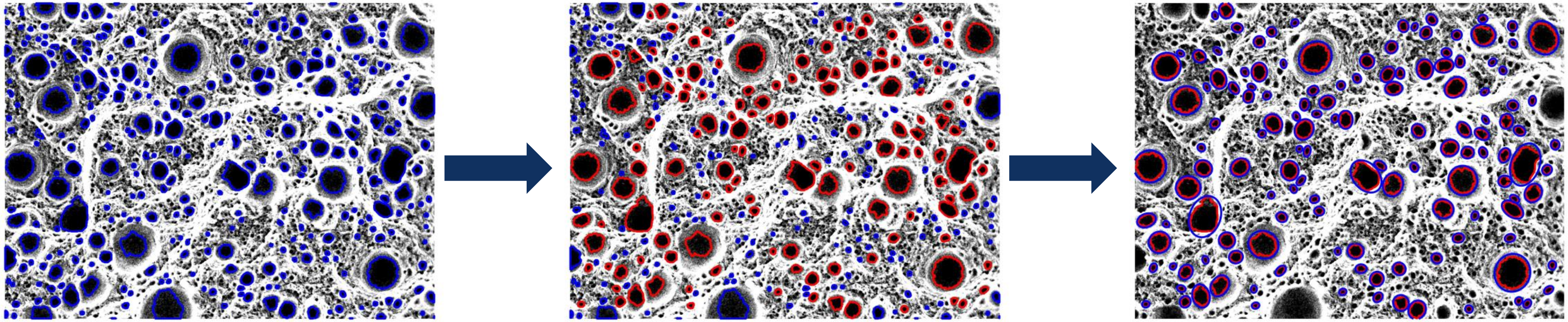
1. Contrast Adjustment
2. Binary Thresholding

Void Detection



1. Contrast Adjustment
2. Binary Thresholding
3. Meet Void Criteria

Void Detection



1. Contrast Adjustment
2. Binary Thresholding
3. Meet Void Criteria
4. Fit and Expand Ellipse

Void Detection

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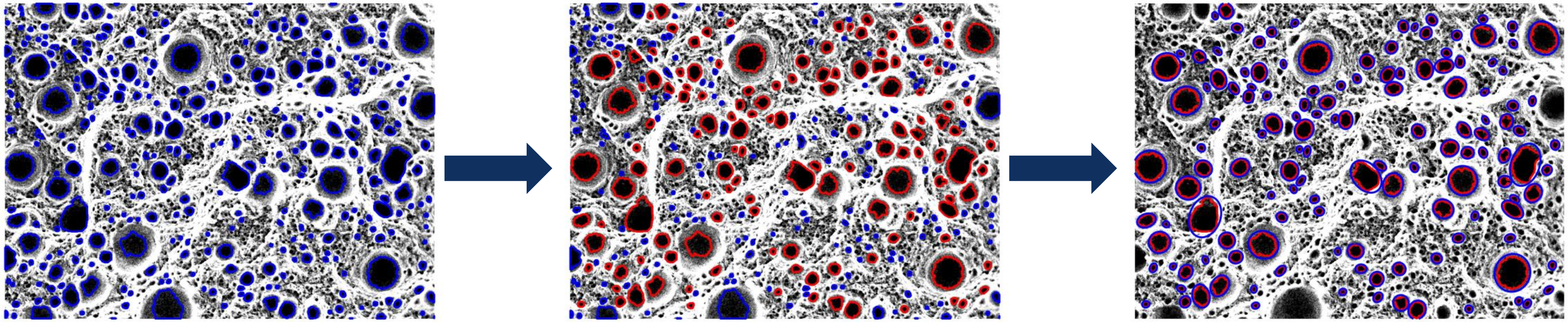

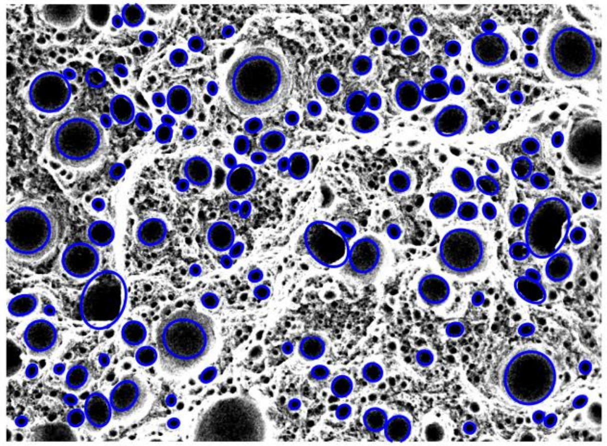

1. Contrast Adjustment
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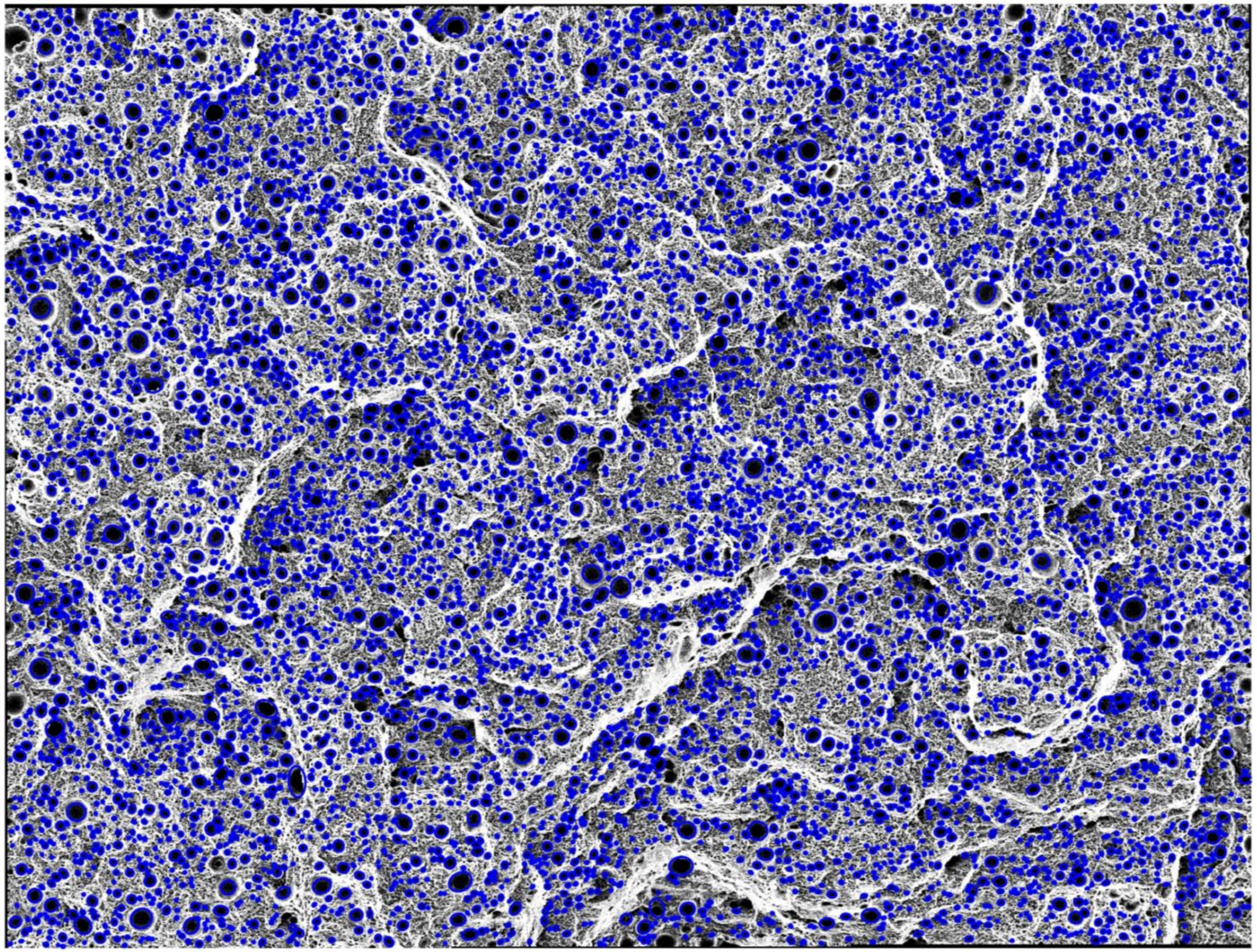
Void Boundaries Marked



Porosity and Ductility by Build

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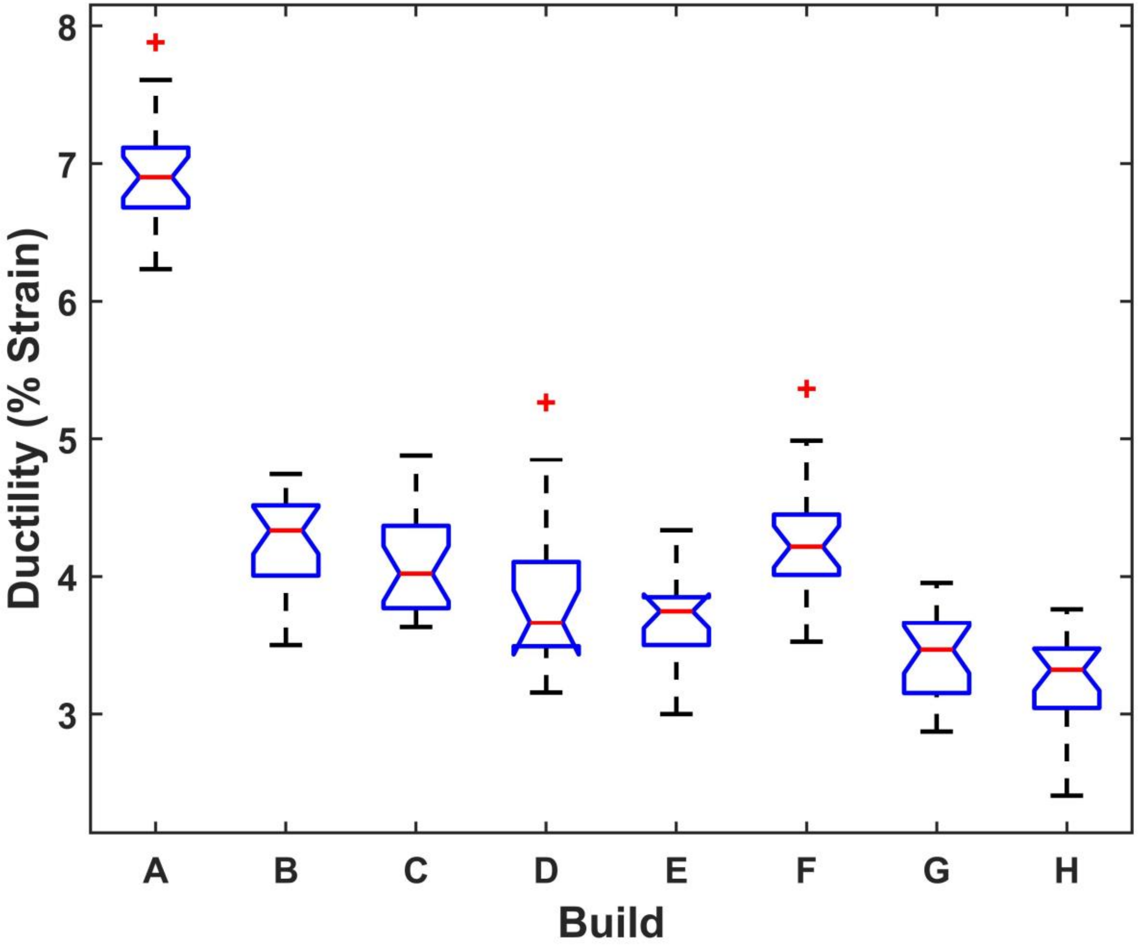
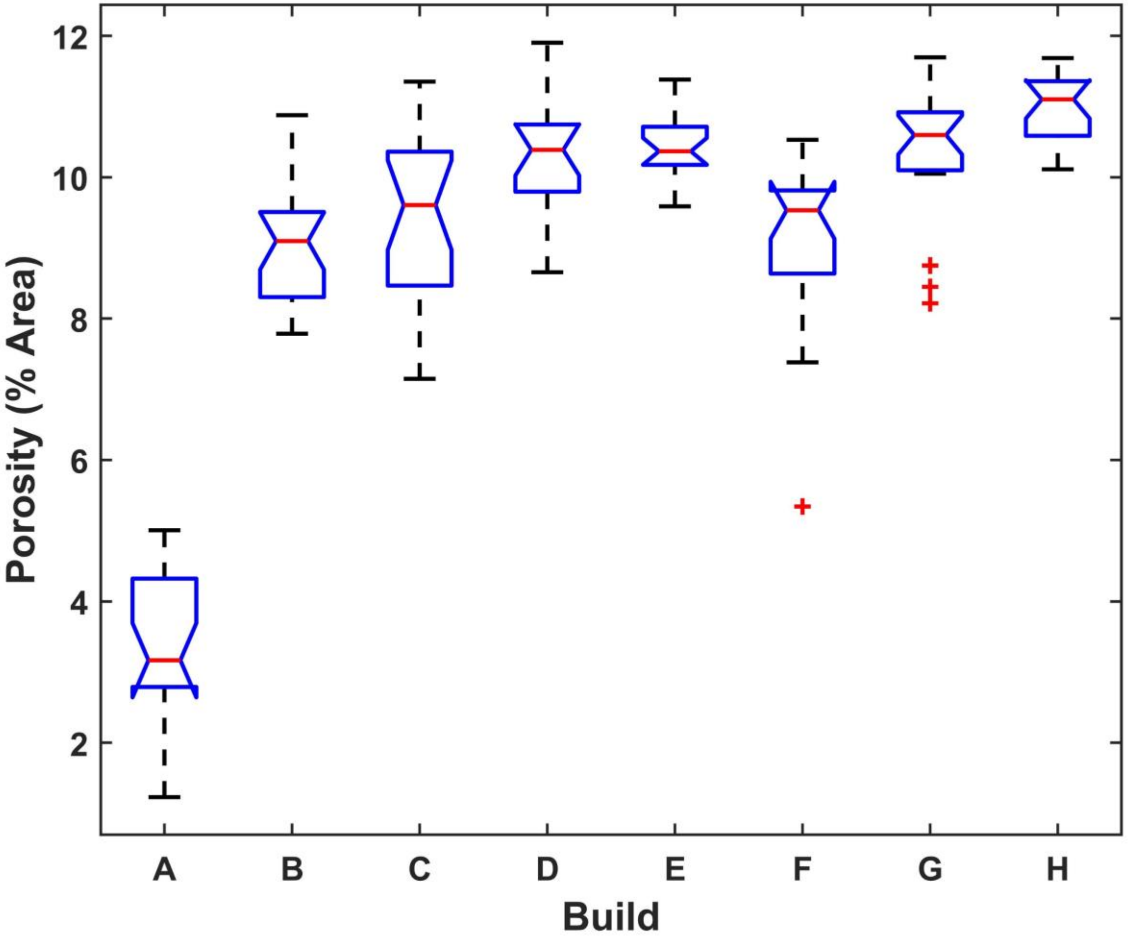
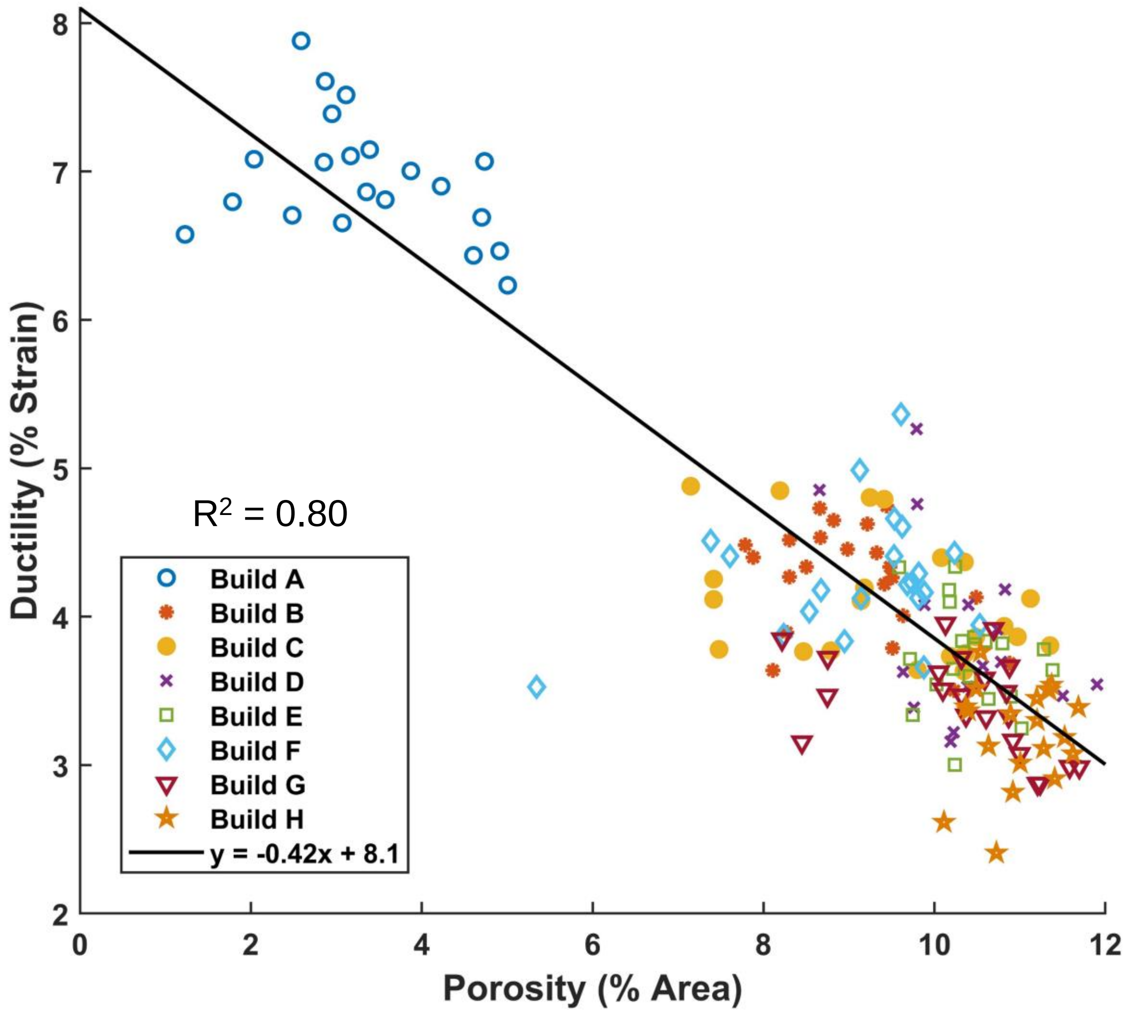
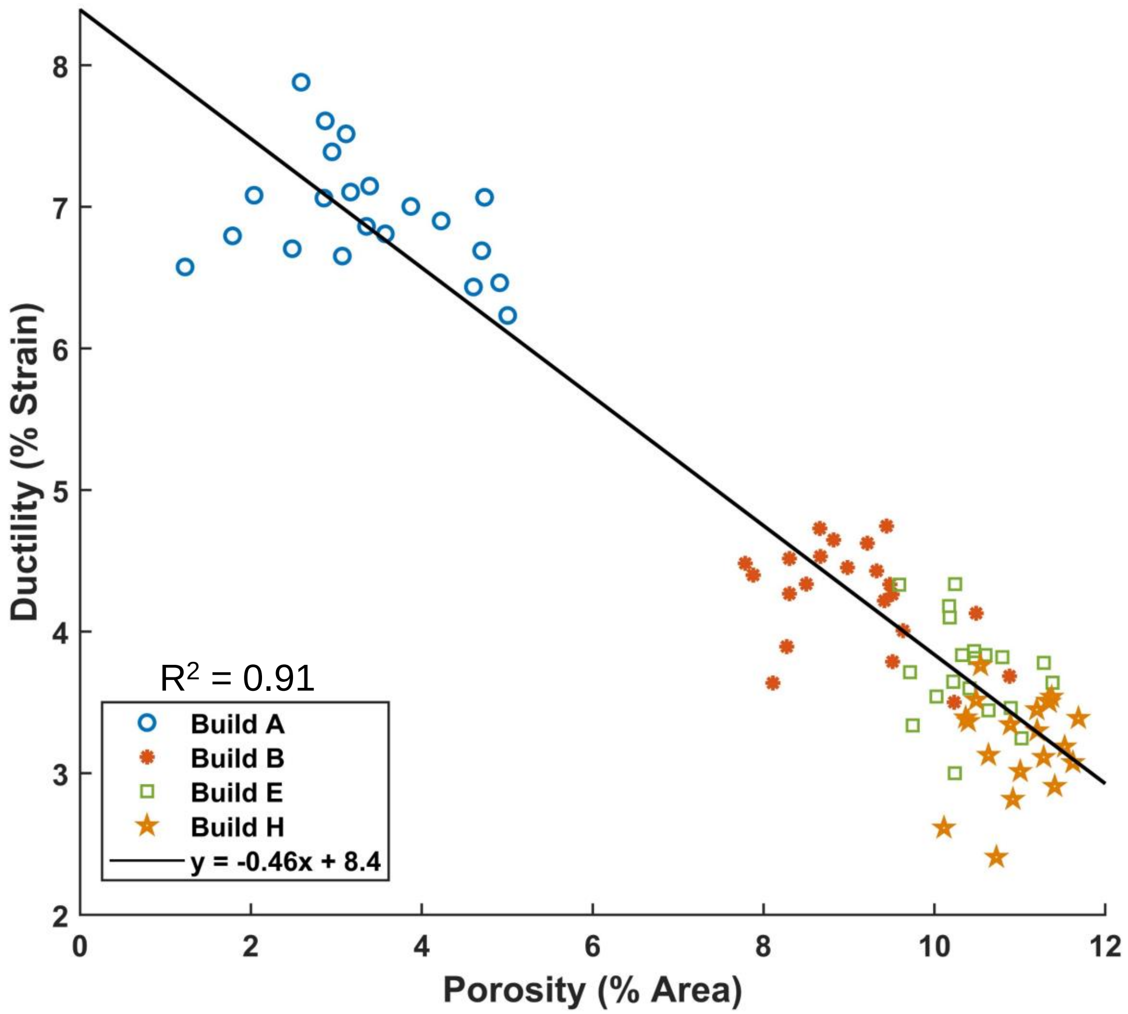




Ductility as Function of Porosity

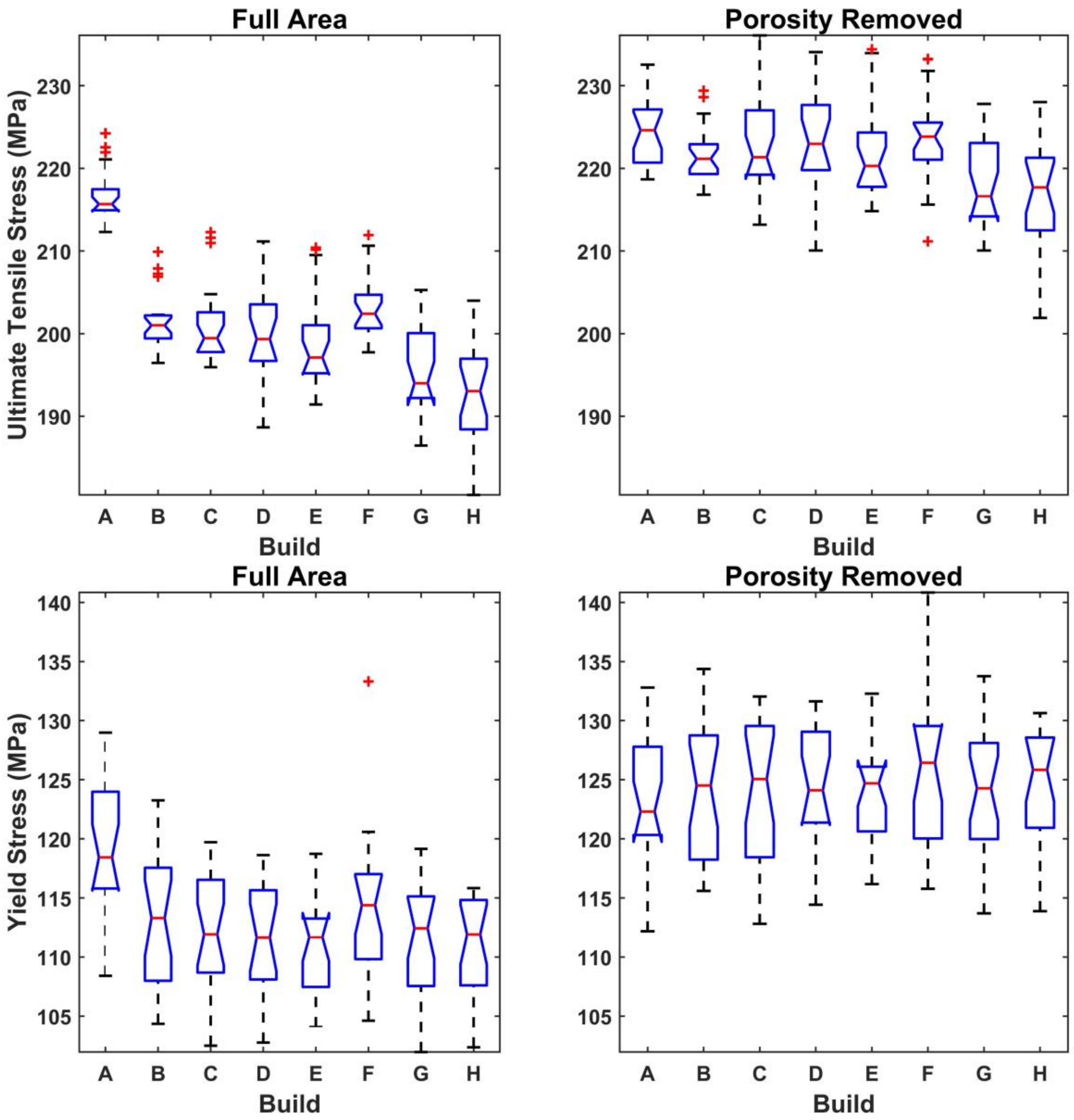


Ductility as Function of Porosity

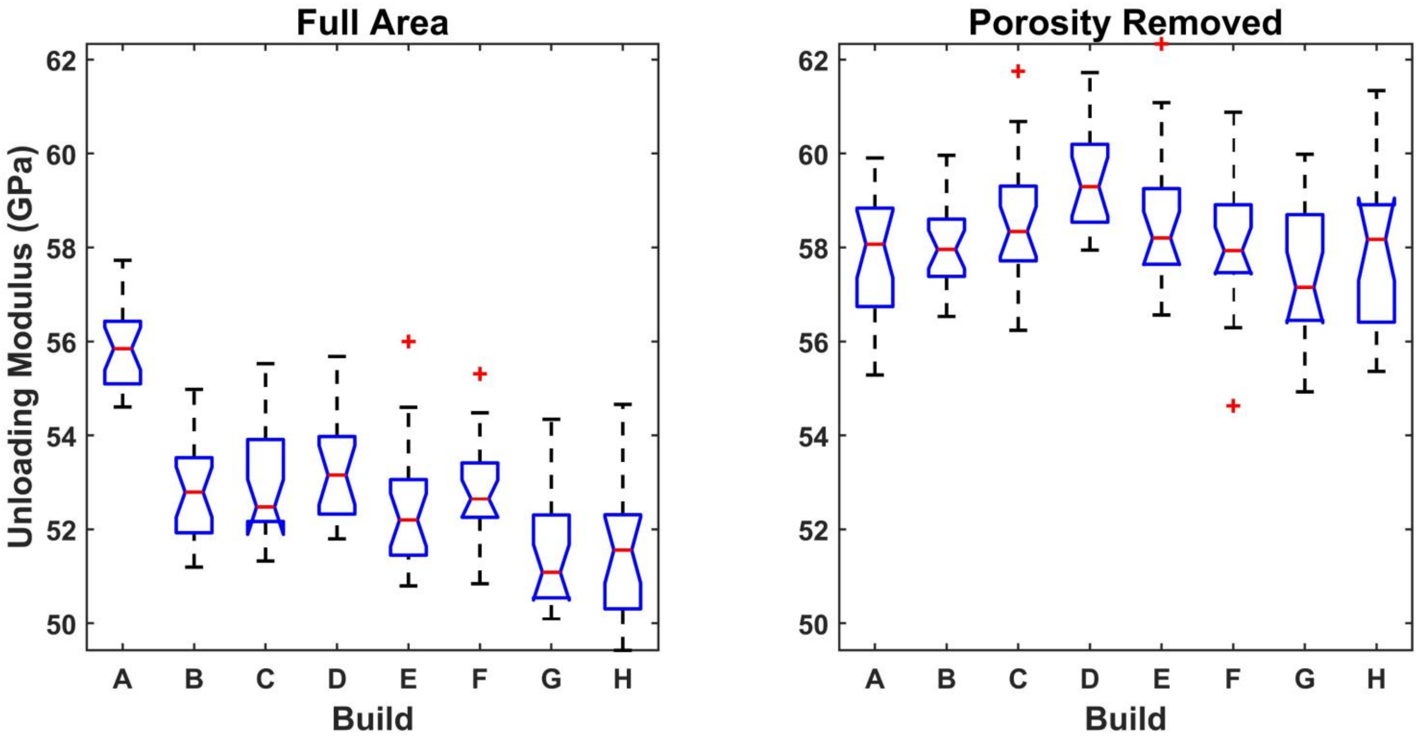


Adjusting Area Values

- Values estimated from stress-strain curves are affected by inaccuracies in area measurements
- Adjust the values for porosity to get an estimate of parameters in the absence of porosity
- See a reduction in the variability between build plates

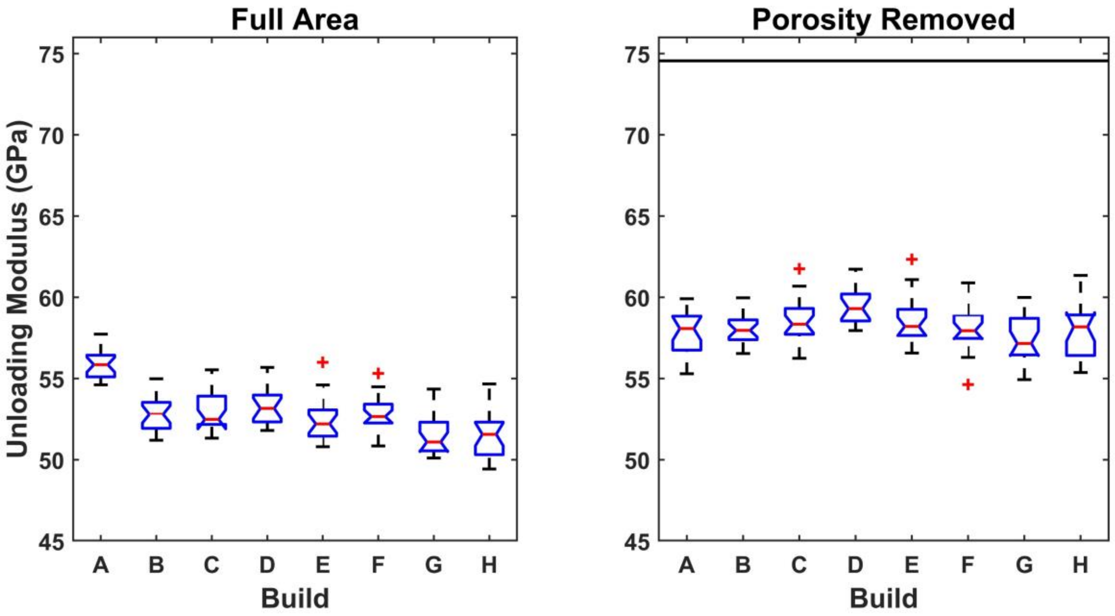


Adjusting Area Values



Compared to Ultrasound Unloading Modulus

- Unloading modulus measured by ultrasound is 74.5 Gpa
- Suggests that other factors are complicating estimates of true area



Future Directions

- Able to estimate void fraction at the fracture surface from SEM images
- Showed that ductility decreases with increasing porosity
- Adjusting the area estimate for porosity reduces variability between builds, but does not account for full range of variability in samples