

Process Plateaus, Not Peaks, in Laser-Powder Bed Fusion

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Motivation

- AM metal qualification remains a challenge

- what are process tolerances & margins?
- does a truly optimal process state exist?

Exploring Process Space

- Parameters
 - 316L stainless steel on 3D Systems ProX 200
 - laser power: 10-240W
 - velocity: 50-2800mm/sec
 - 30 μ m layer thickness, 50 μ m cross-feed
- Performance metrics
 - surface finish, form error, density, tensile properties, microstructure

Density Cubes

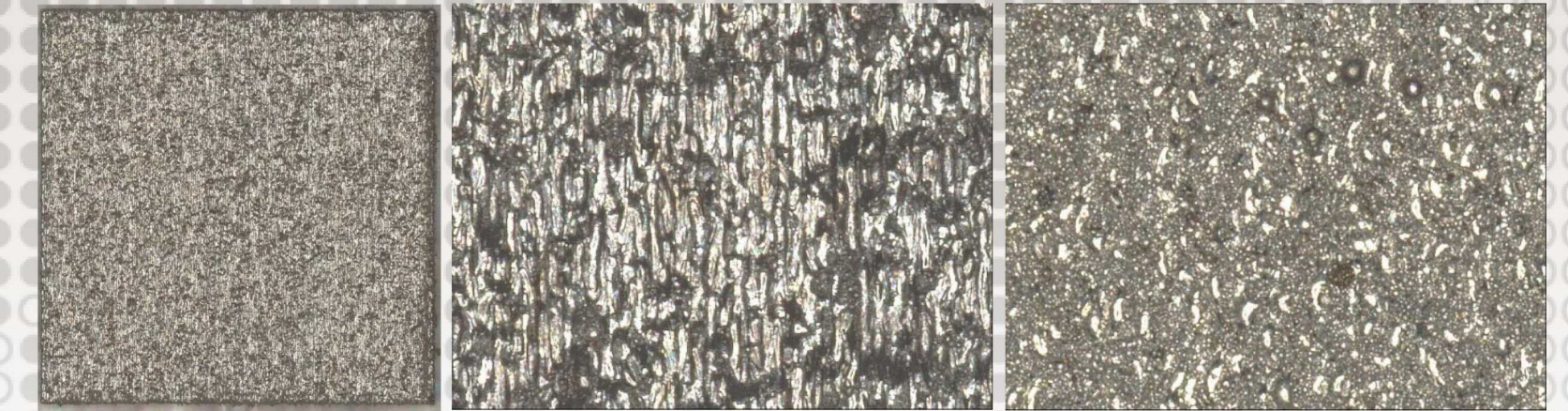
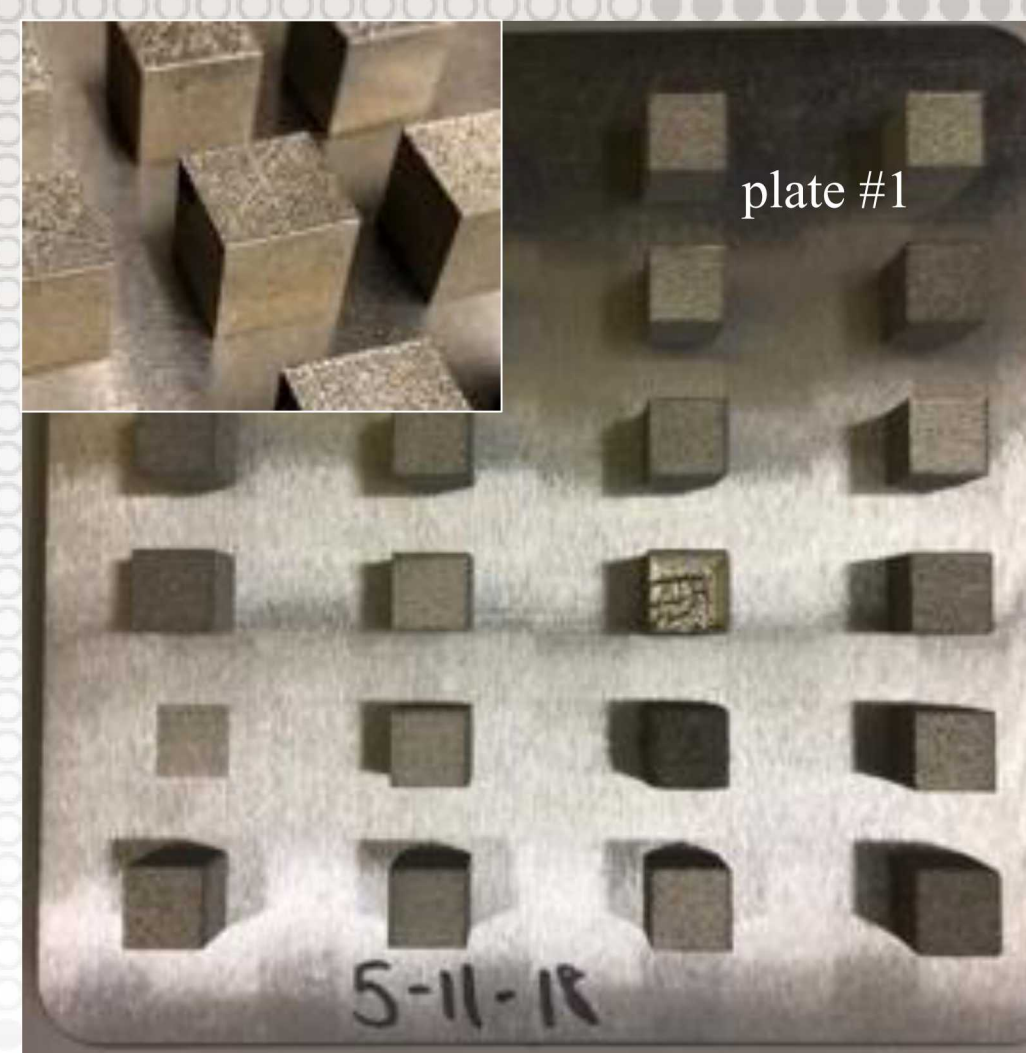
- 1cm cubes, 24 per plate
 - varied power & velocity
- Bulk material measurements
 - density (Archimedes)
 - top & side surface form & finish
 - microstructure: optical, EBSD

High-Throughput Tensile Properties

- 1x1x4mm gauge section
 - 10 or 25 dogbones/array
 - varied power & velocity
- >500 dogbones tested
 - density (Archimedes)
 - surface roughness
 - UTS, YS, modulus, ductility

Summary

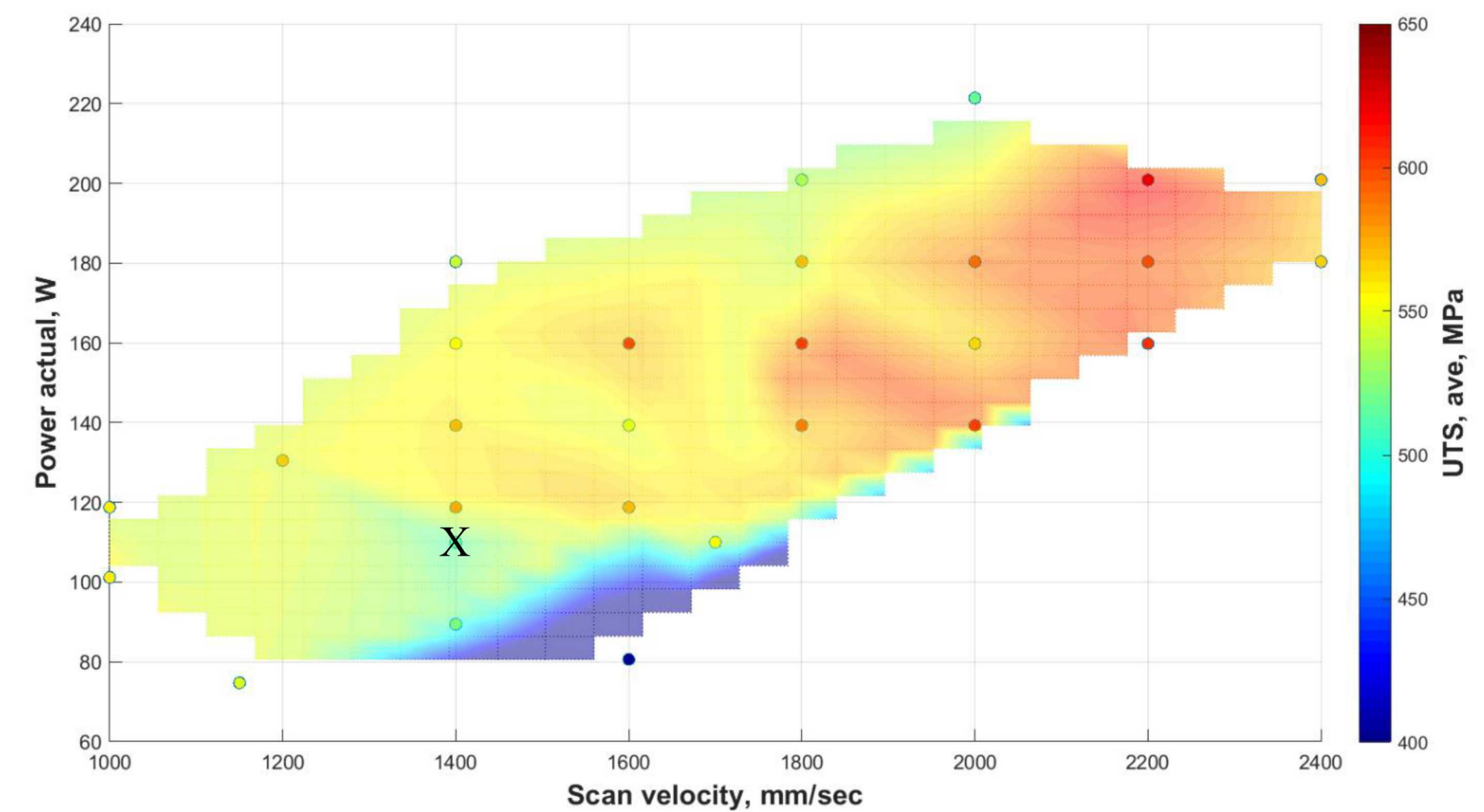
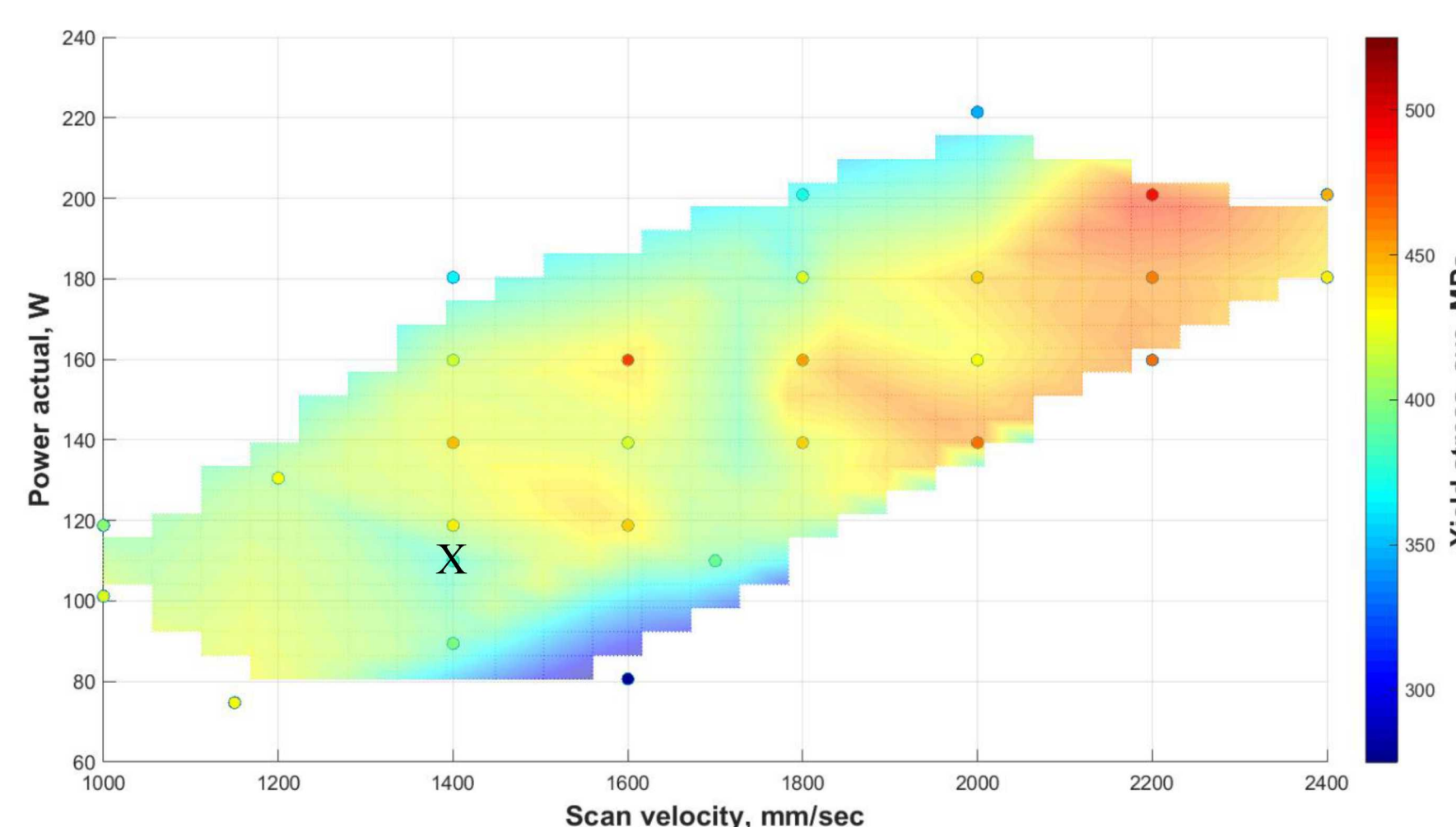
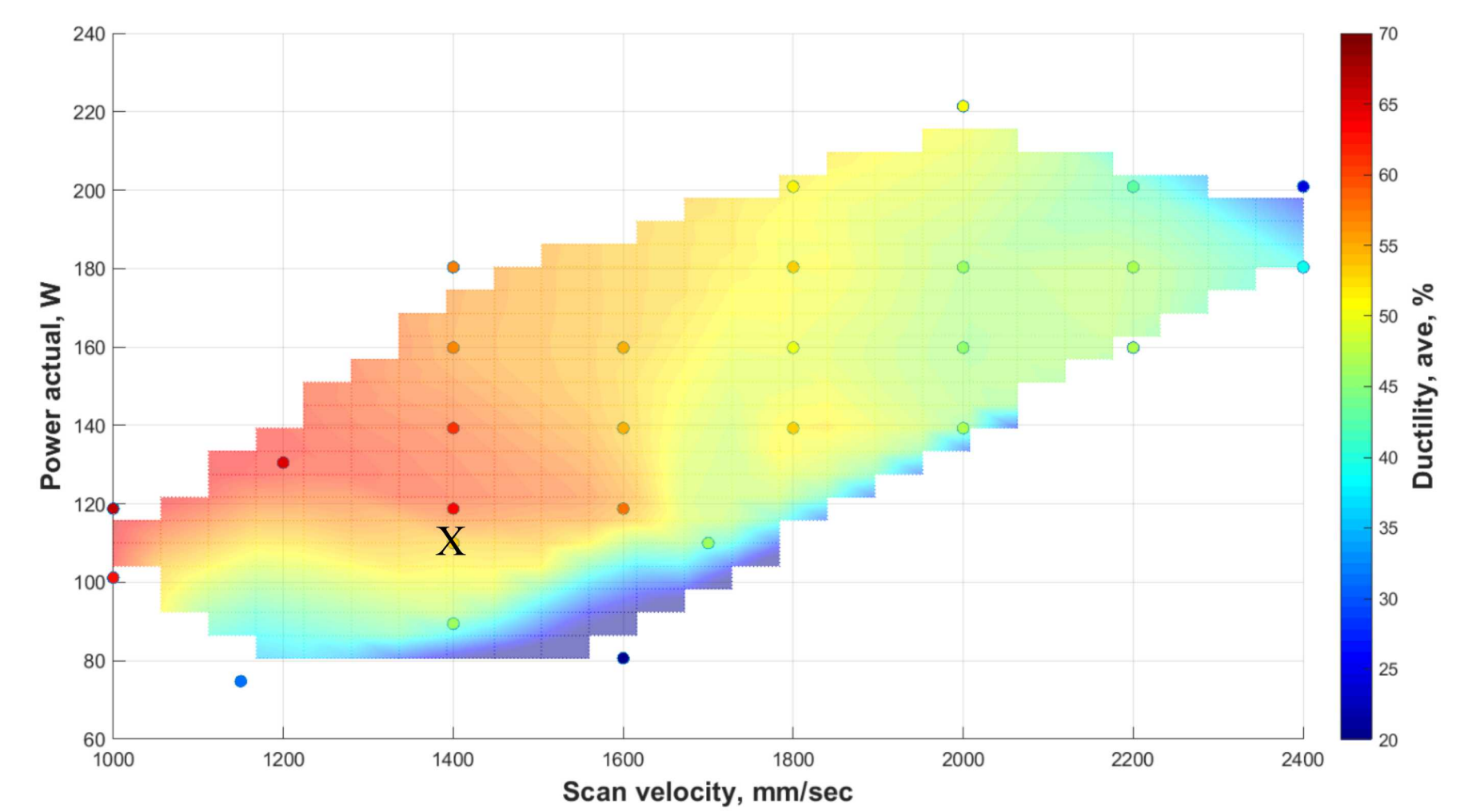
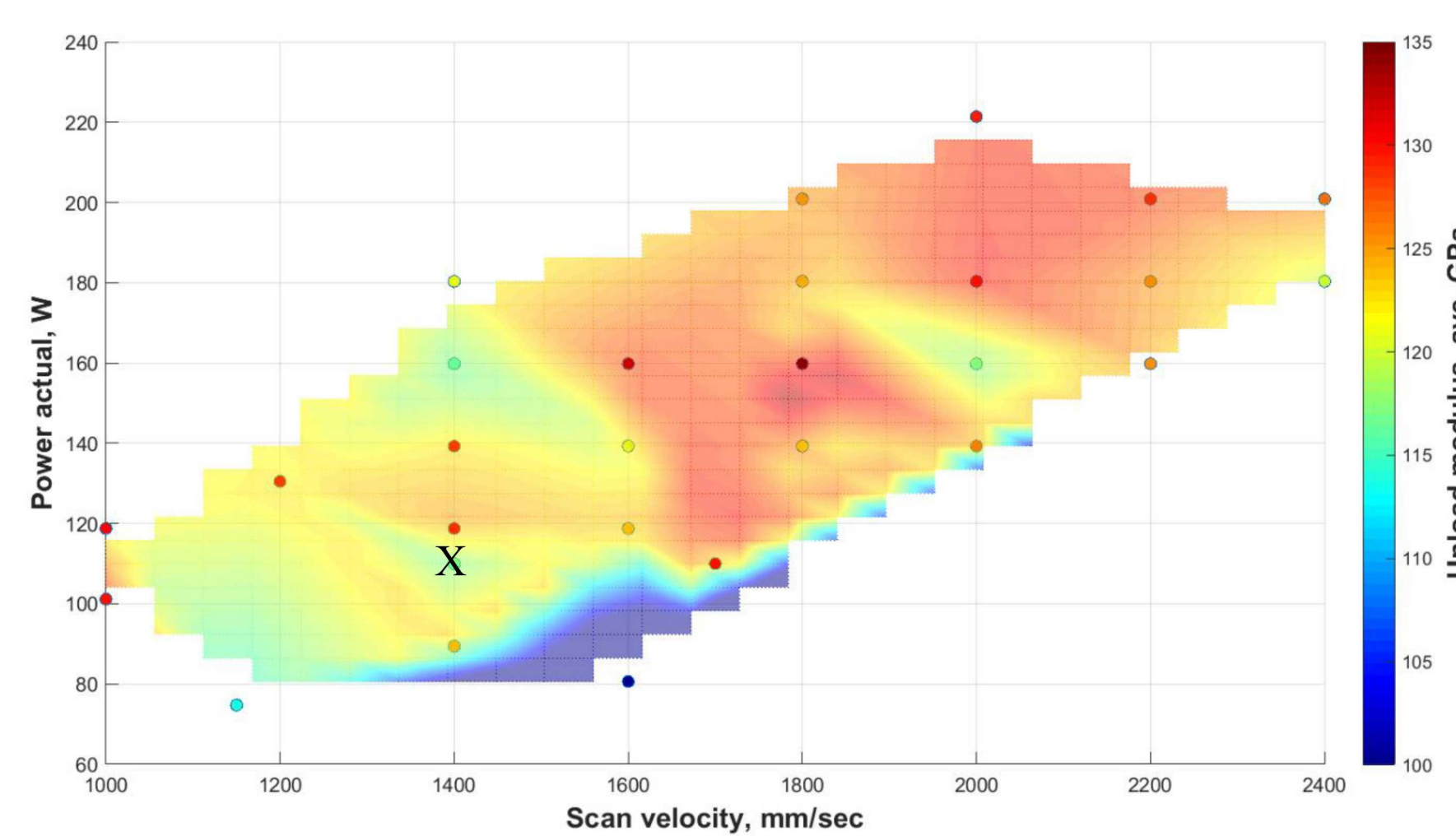
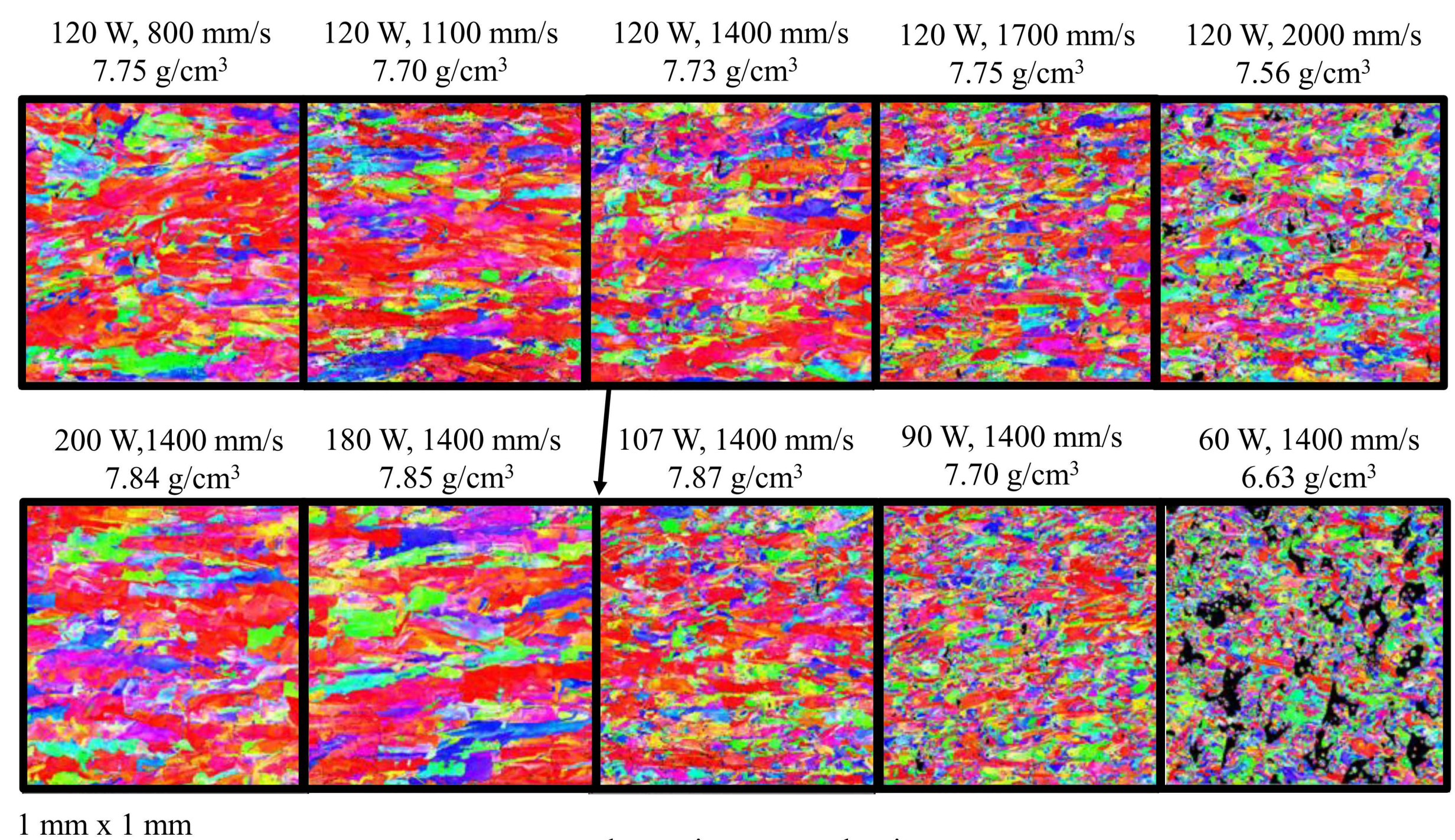
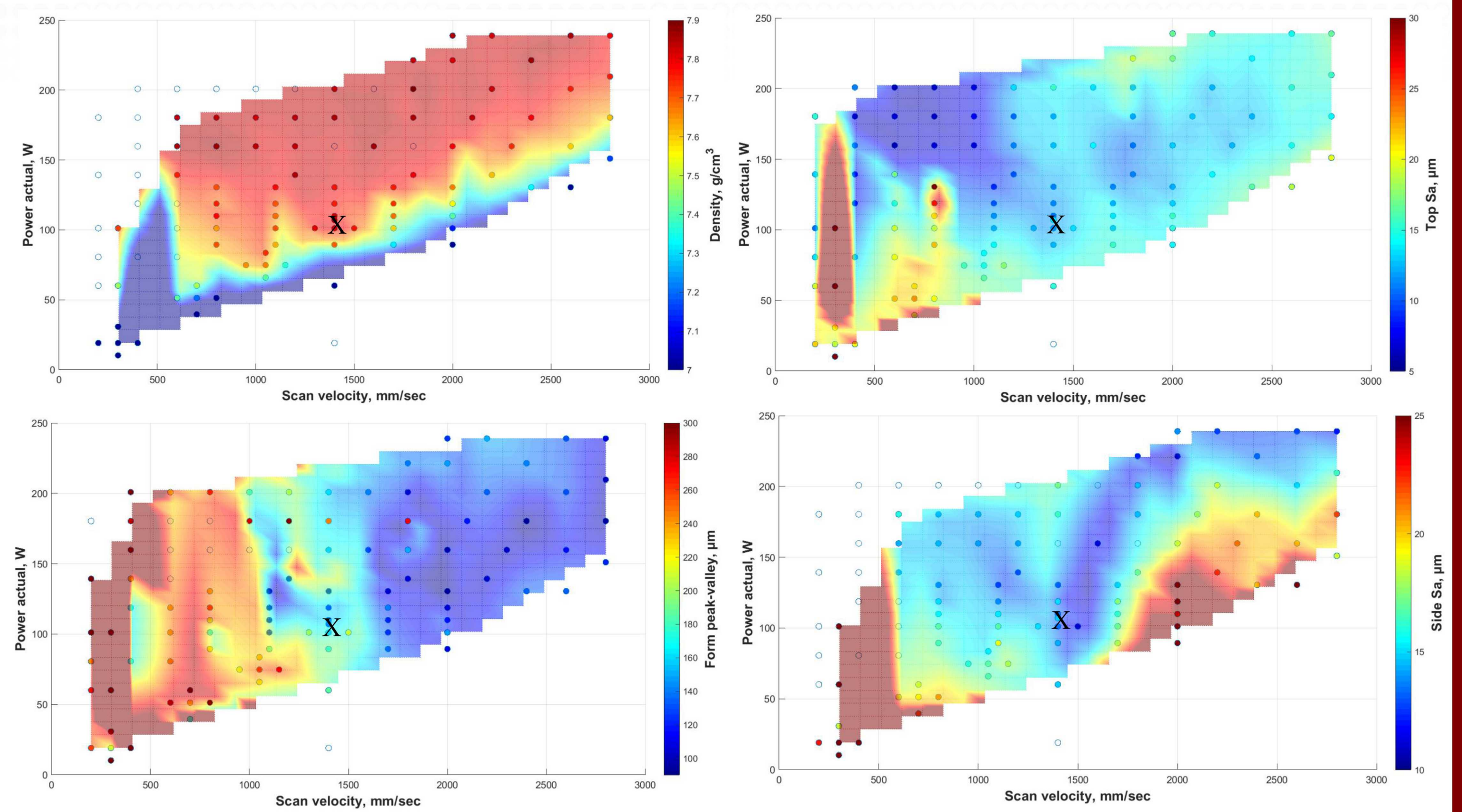
- Density cubes, metallurgy & tensile testing are required for detailed, precise understandings
 - observe property & microstructure control
- Extensive characterization shows that process performance is a plateau, not a point
 - be careful claiming “optimization”
 - manage property & manufacturability trades
 - density isn’t a definitive process metric



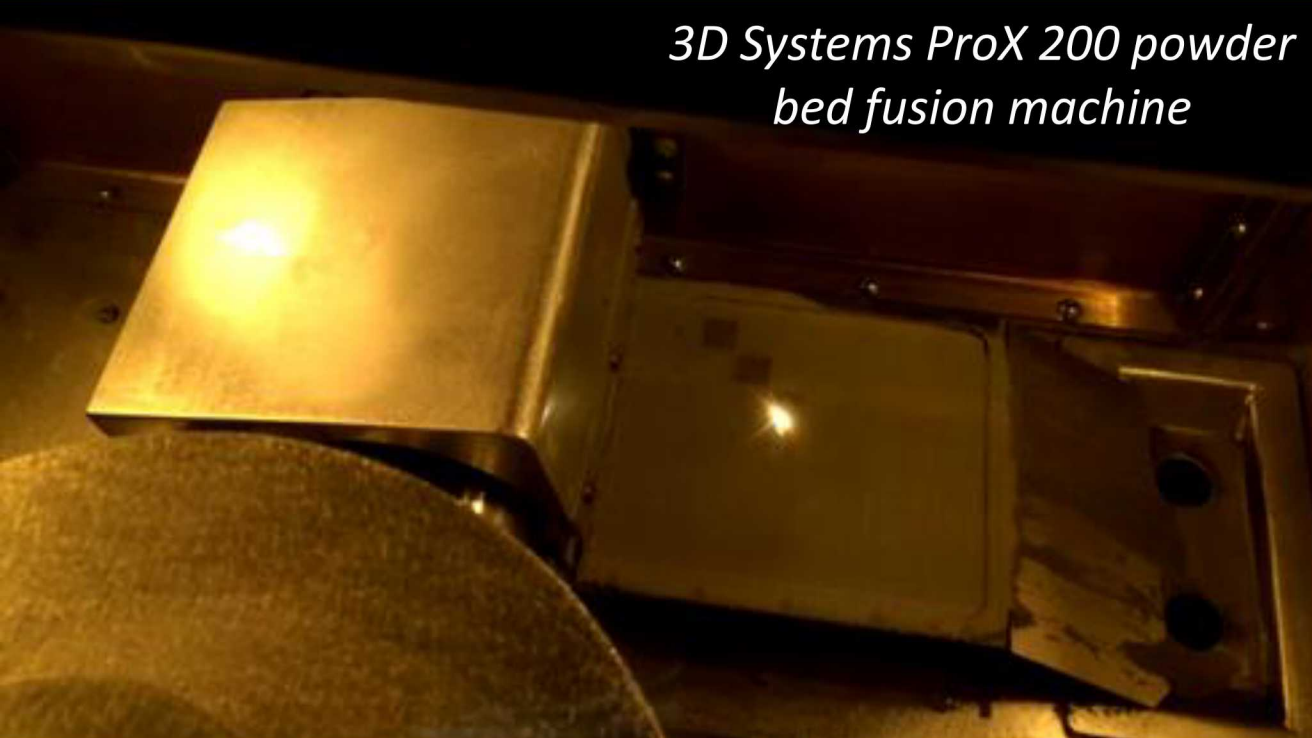
100.2W, 1500mm/sec, top 209 μ m PV form (left), top 13.5 μ m S_a roughness (center), side 9.98 μ m S_a roughness (right)



60.1W, 300mm/sec, top 891 μ m PV form (left), top 73.8 μ m S_a roughness (center), side 38.1 μ m S_a roughness (right)



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3D Systems ProX 200 powder bed fusion machine



316L SS dogbone array with 25 dogbones