INL/CON-22-68926-Revision-0

Additive Manufacture of Multi-Functional, Large-Scale Components

September 2022

Thomas M Lillo, Michael V Glazoff, Eric C Larsen, Denis Clark, Jason K Walleser, Tate Patterson

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Title: Additive Manufacture of Multi-functional, Large-scale Components

PRESENTER:

Thomas Lillo

BACKGROUND: Extreme environments place more demands on materials. Functionally-grade materials (FGM) can address local operating conditions at reduced cost. However, a cost-effective fabrication method is needed for FGMs.

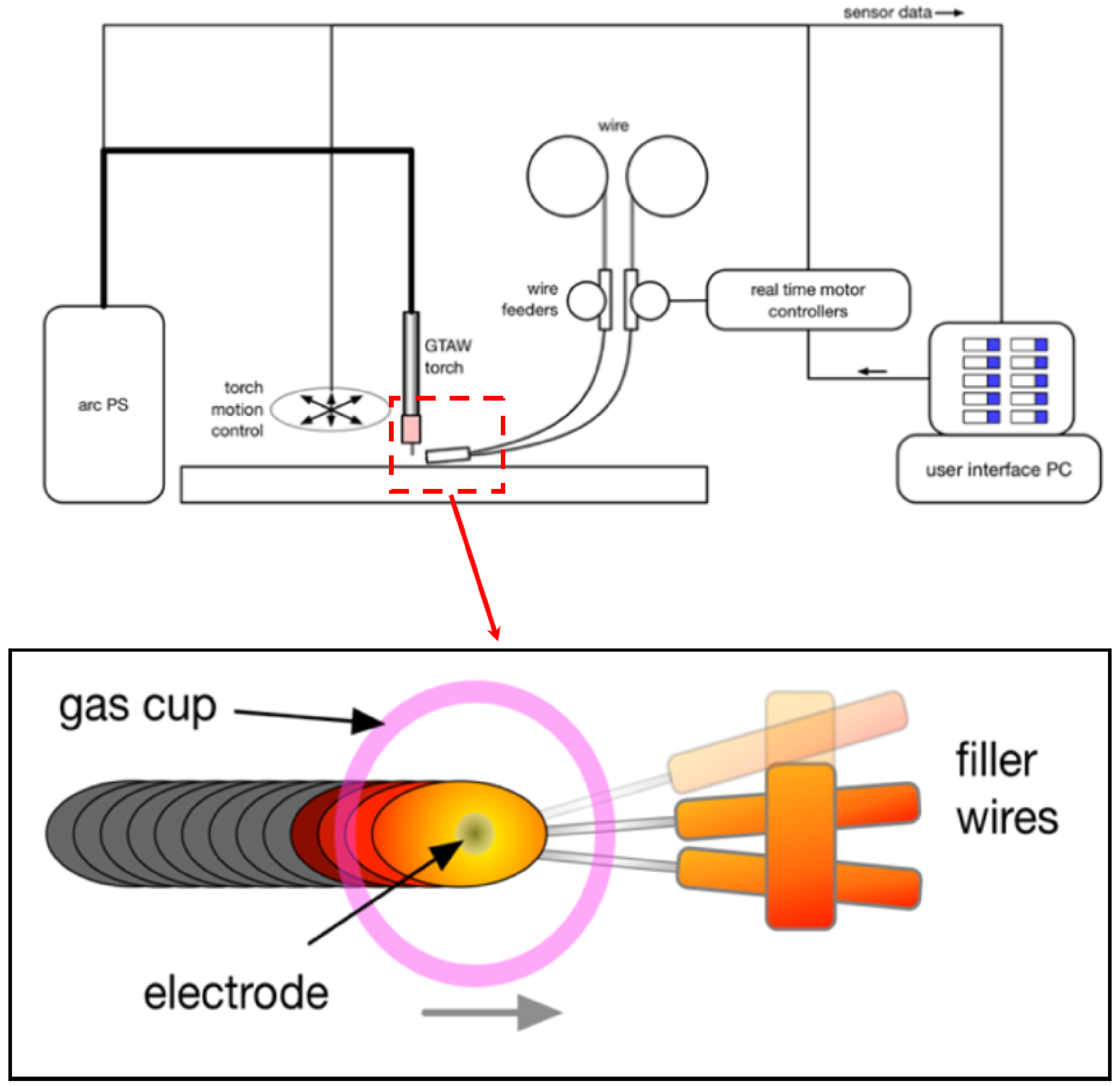
METHODS

1. Modified standard welding system to deliver up to 3 wires during deposition
2. Explored effect of deposition parameters on resulting composition gradient
3. Combined heat treatments with composition gradient to obtain components with graded microstructure with the potential for improved dynamic impact performance

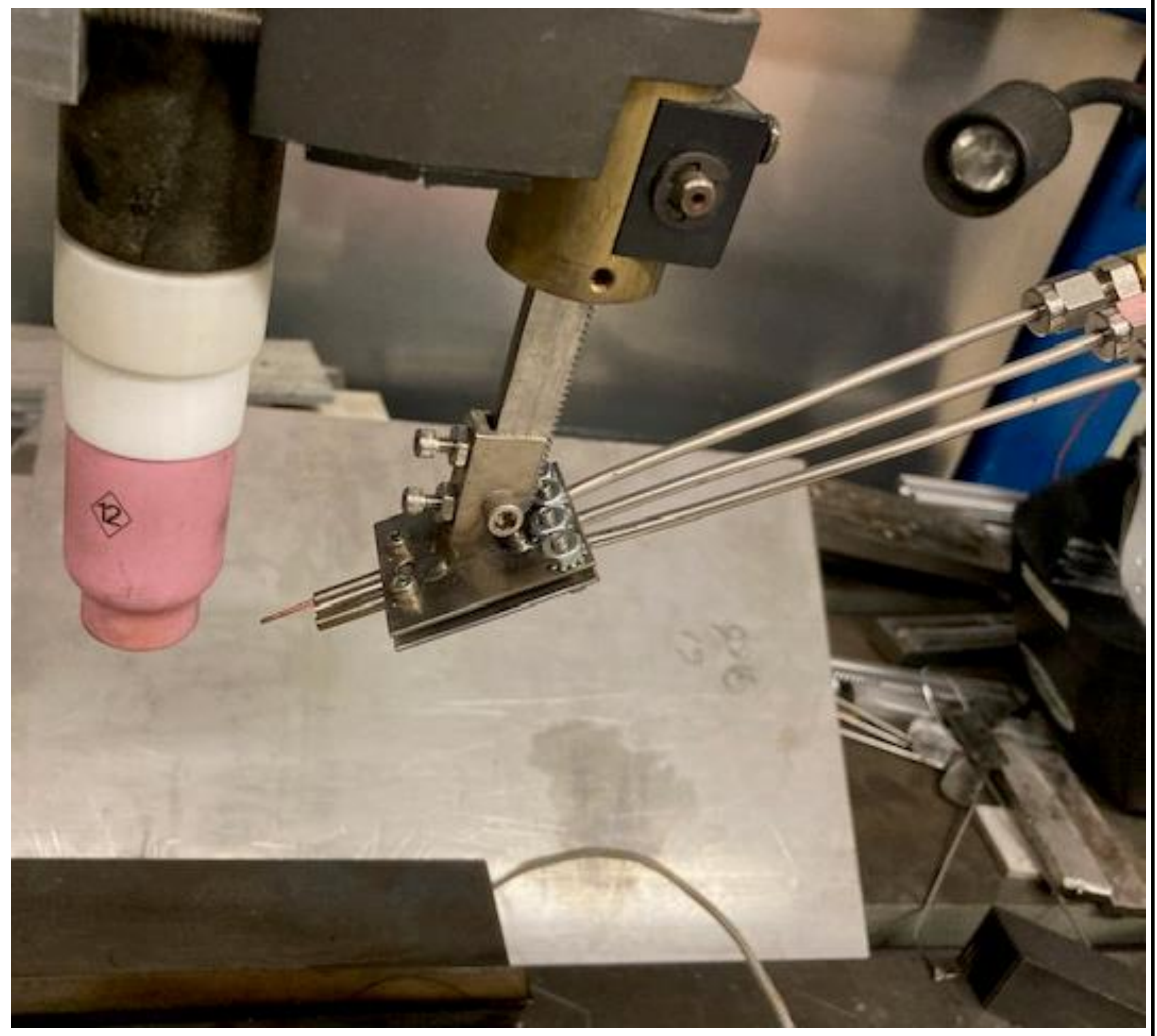
RESULTS

- **Various graded shapes fabricated**
- **Deposition parameters influence the resulting composition gradient**
- ***M-WAAM is viable AM method for FGM fabrication***

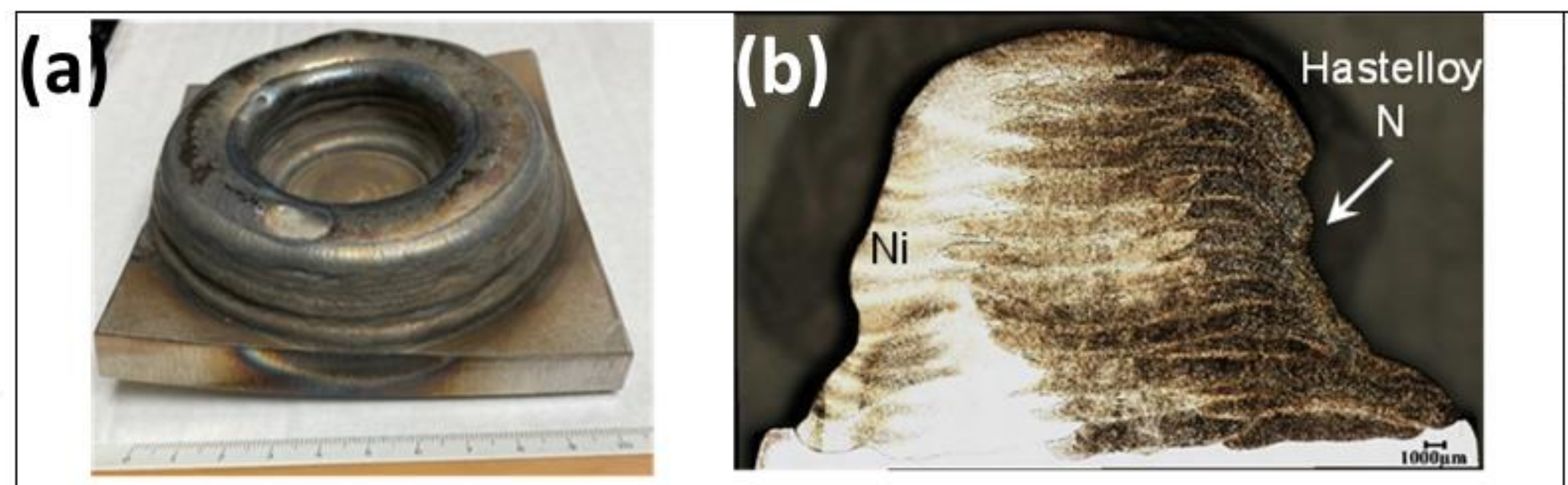
Development of Automated Multi-wire Arc Additive Manufacturing (m-WAAM) For FGMs



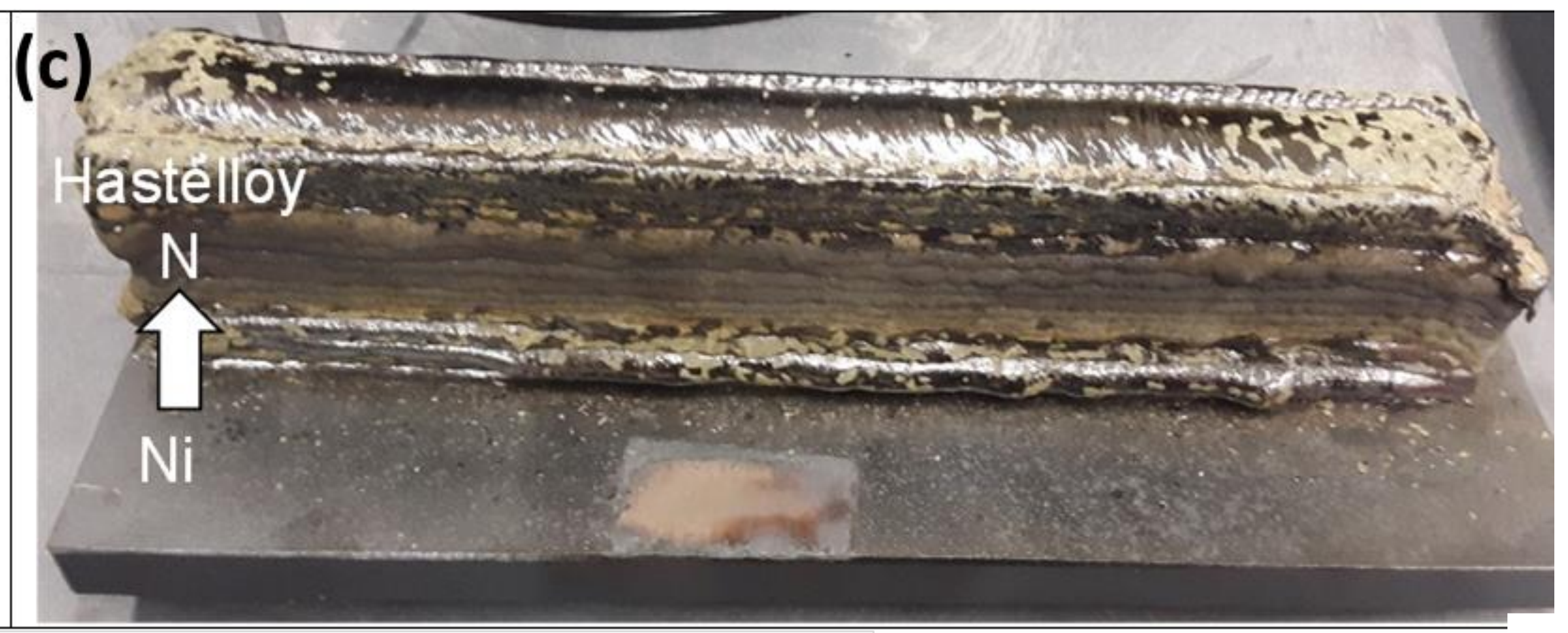
Schematic of System

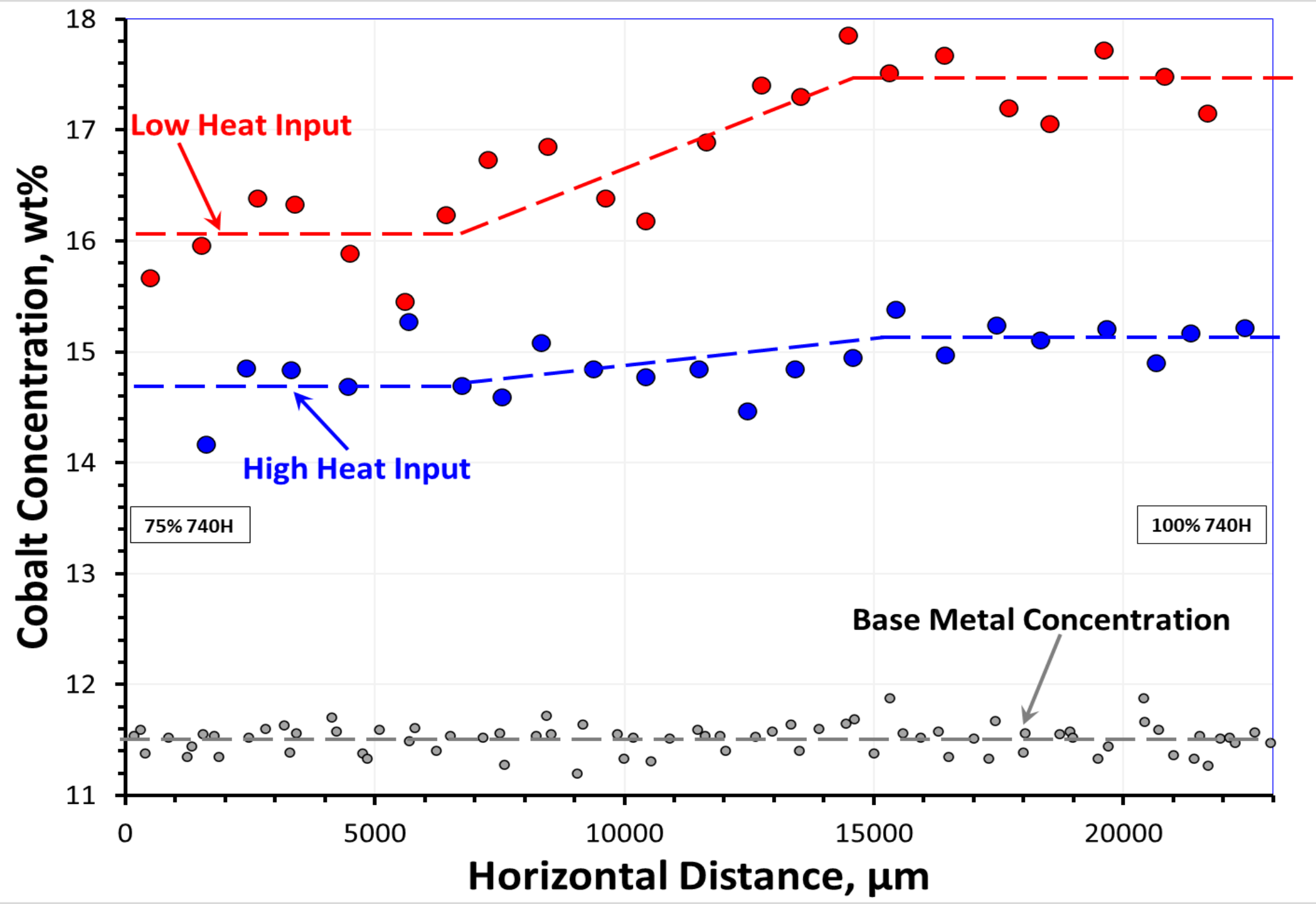


3-wire delivery guide

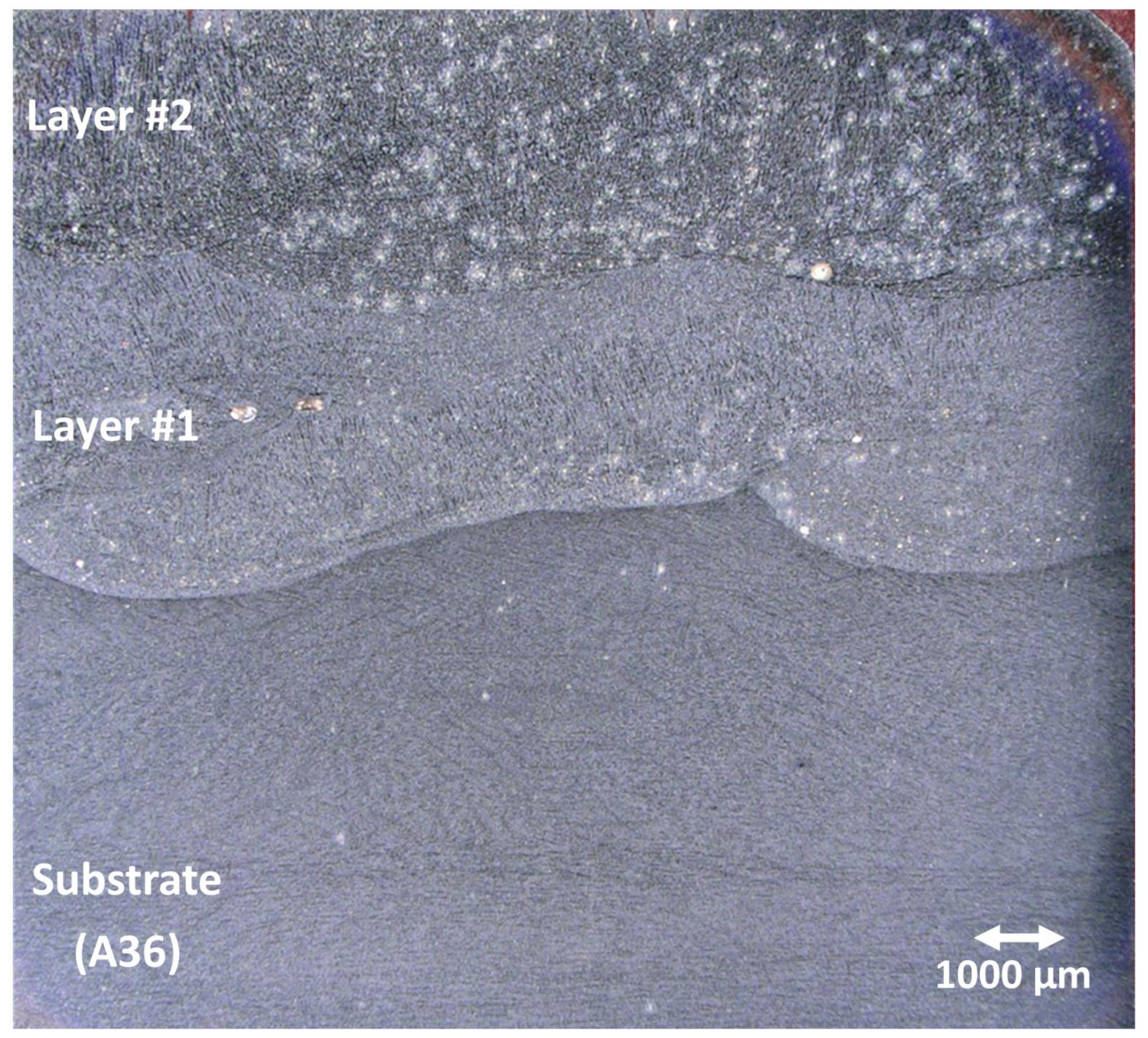


Composition Gradient Across Pipe Wall (Hastelloy N to Ni)
(~0.67 kg/hr)





m-WAAM Deposit



Layer Composition

Layer 2

Element	Weight %
Si K	0.60
Cr K	0.10
Mn K	1.20
Fe K	98.10
Ni K	0.10

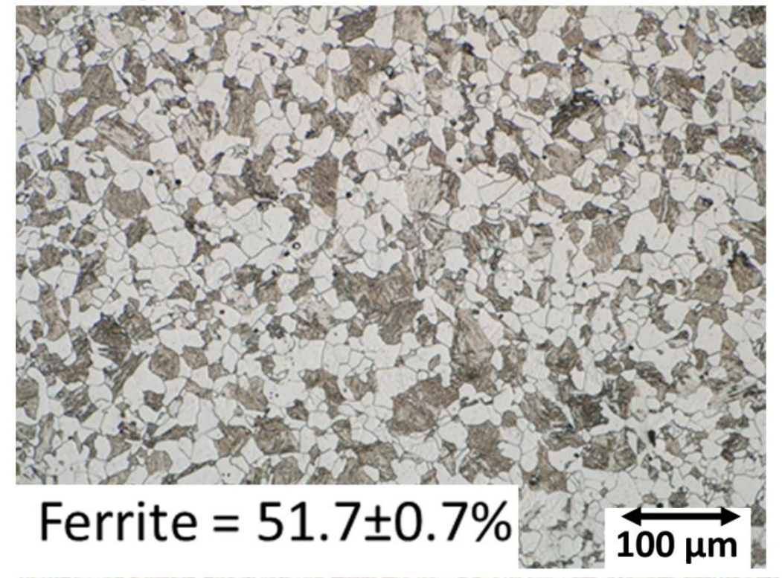
Layer 1

Element	Weight %
Si K	0.47
Cr K	0.10
Mn K	0.90
Fe K	98.43
Ni K	0.20

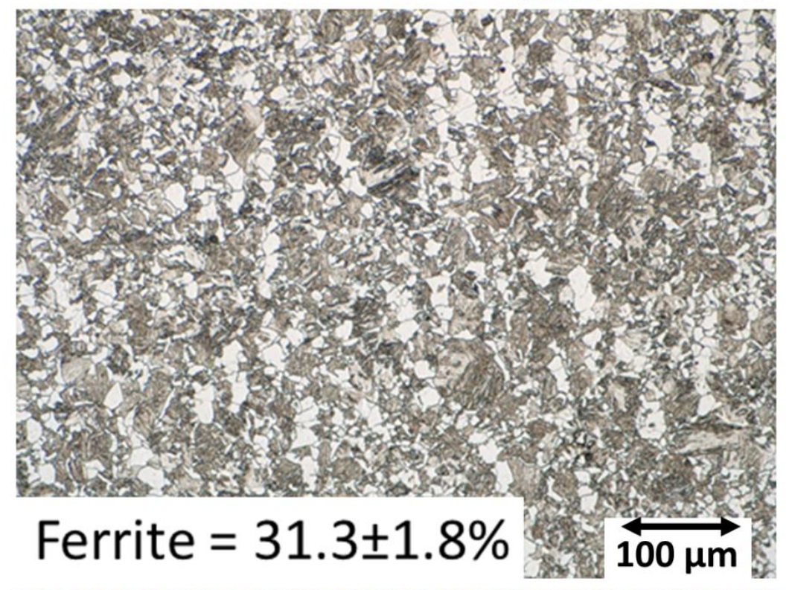
Substrate

Element	Weight %
Si K	0.10
Cr K	0.20
Mn K	0.73
Fe K	98.97
Ni K	0.00

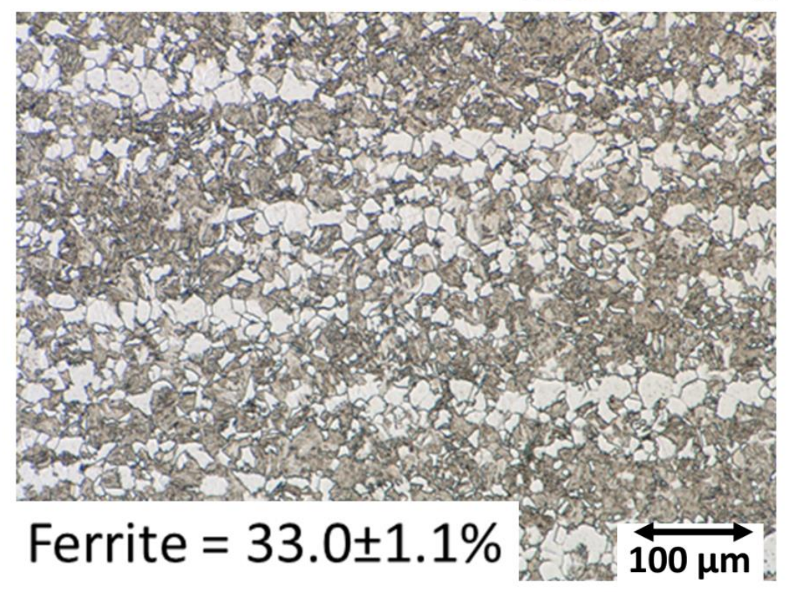
Layer Microstructure



Ferrite = 51.7±0.7%

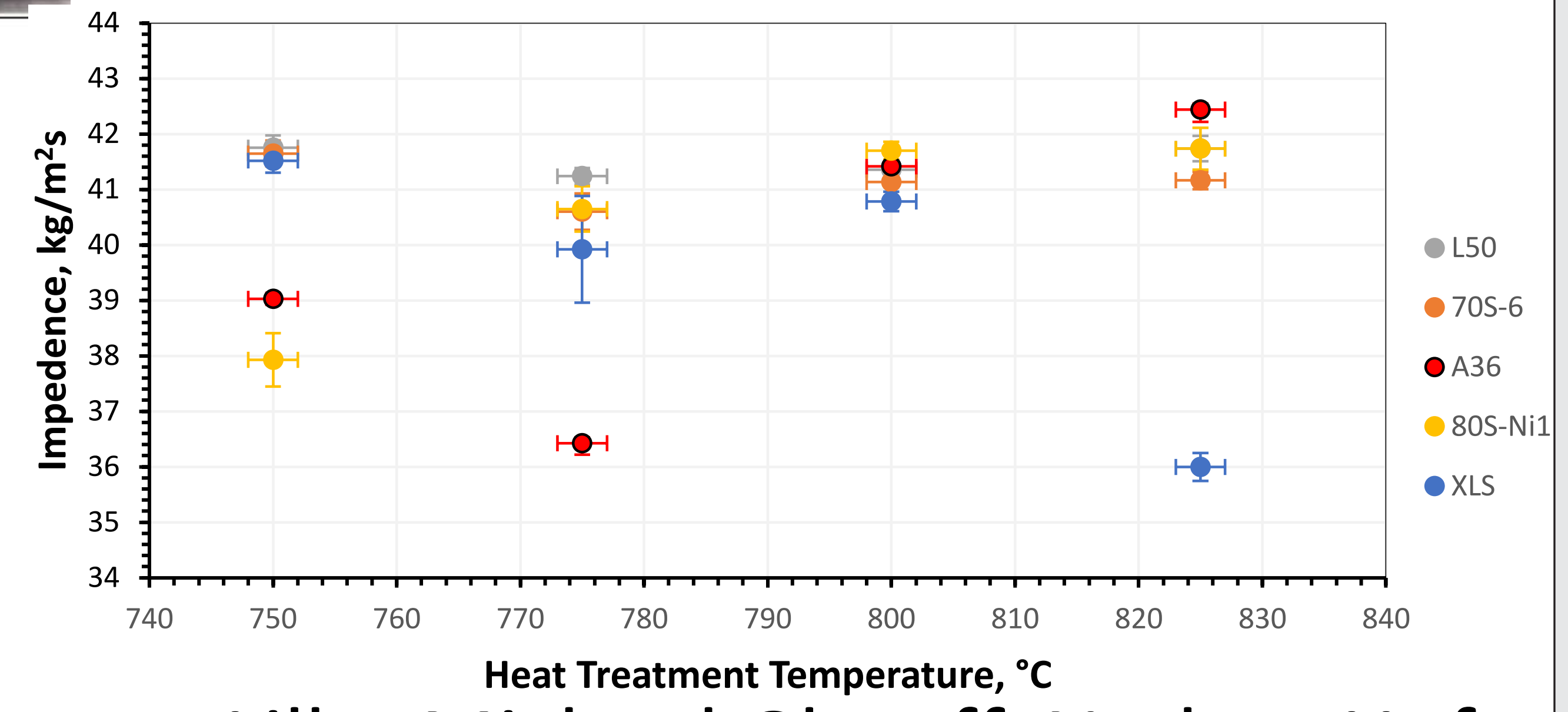


Ferrite = 31.3±1.8%



Ferrite = 33.0±1.1%

Gradient Microstructures



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Project Number: **20A44-113FP**

LRS Number: INL/CON-22-68926

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Work supported through the INL Laboratory Directed Research & Development (LDRD) Program under DOE Idaho Operations Office Contract DE-AC07-05ID14517."

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy

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