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TITLE

Characterization of a Nickel Aluminum Bronze Laser-Clad Weldment

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Characterization of a Nickel Aluminum Bronze Laser-Clad Weldment

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ABSTRACT

The microstructural and compositional variations that exist across a laser-clad weldment produced with a heat input of 150 J/cm and filler wire composition Cu-9.0% Al, 4.6% Ni, 3.9% Fe and 1.2% Mn have been characterized. The weld metal, heat-affected zone and casting base metal structures and elemental distributions were evaluated using light optical microscope and electron microprobe, respectively. The results show that a considerable range of microstructures and some significant compositional variations are present in the laser-clad weldment investigated.

CHARACTERIZATION OF A NICKEL ALUMINUM BRONZE LASER-CLAD WELDMENT

by

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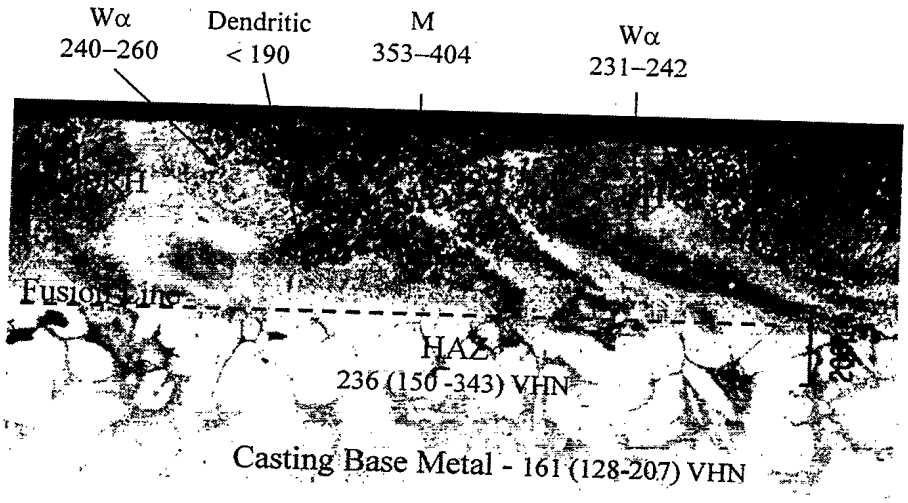
Acknowledgments
Judith Price
Vera Weatherall
Catherine Bibby

Objective

To characterize the microstructural features and corresponding elemental distributions that exist in a low heat input laser clad weldment.

Cross-Section of Laser Clad Weldment



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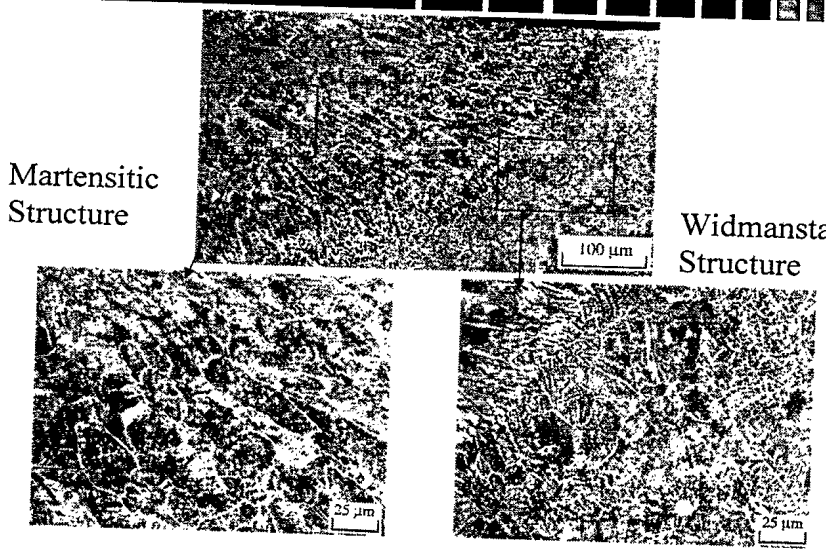
As-Deposited and Reheated Regions



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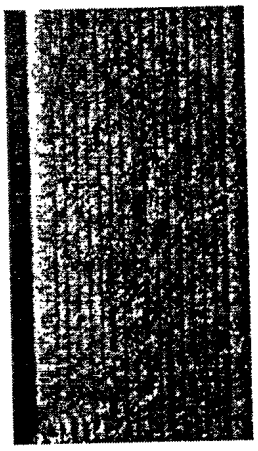
Reference Laser Weld Cladding



- Shielding Gas = Ar
- Laser Power = 3300 W
- Heat Input = 150 J/mm
- Wire Diameter = 0.25 mm
- Overlay consists of alternating as-deposited and reheated weld metal.

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Experimental Approach

- Characterize microstructure optically and
- Use the Cameca SX-51 EPMA to determine elemental distributions for:
  - as-deposited and reheated weld metal
  - fusion zone transition region (dendritic)
  - HAZ
  - casting base metal

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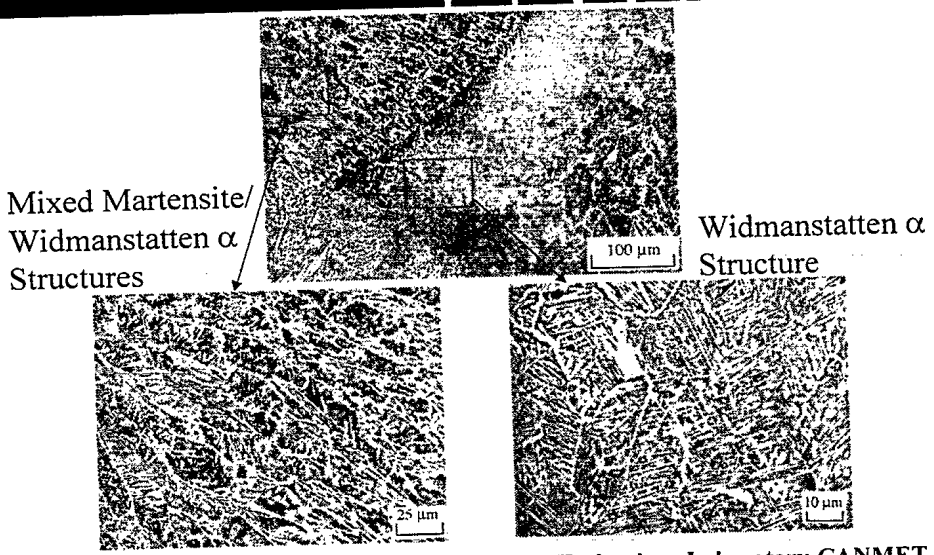
As-deposited and Reheated Regions



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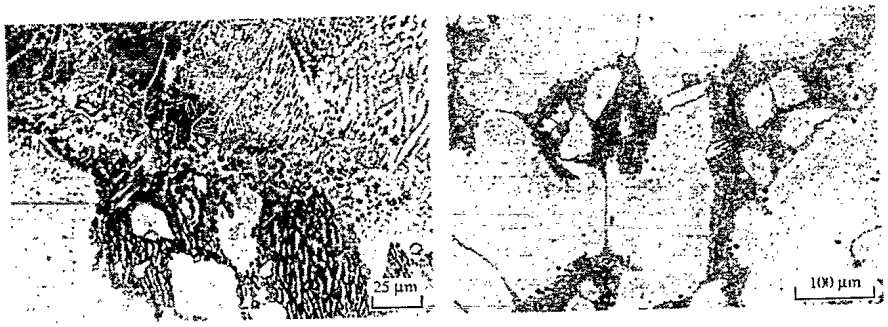
HAZ and Base Metal Structures



HAZ

Base Metal

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Chemical Compositions

		Element (wt %)			
Specimen	Designation	Al	Ni	Fe	Mn
Casting	C95800	8.6	4.7	4.5	1.6
Wire	ER-CuNiAl	9.0	4.6	3.9	1.2
Laser Weld	A150/1	8.7	4.7	4.5	1.5

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Line Scans and X-ray Maps

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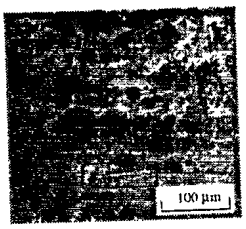
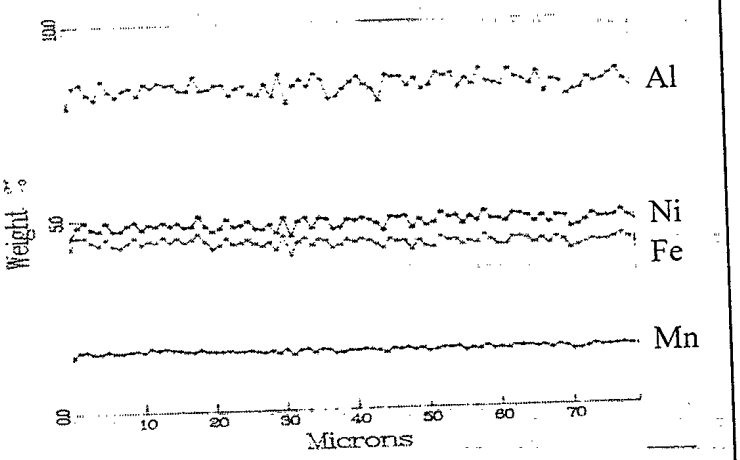
Martensitic Structure

as-deposited weld metal region stage scan





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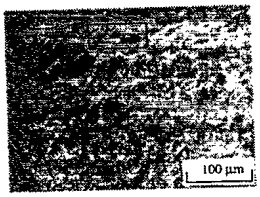
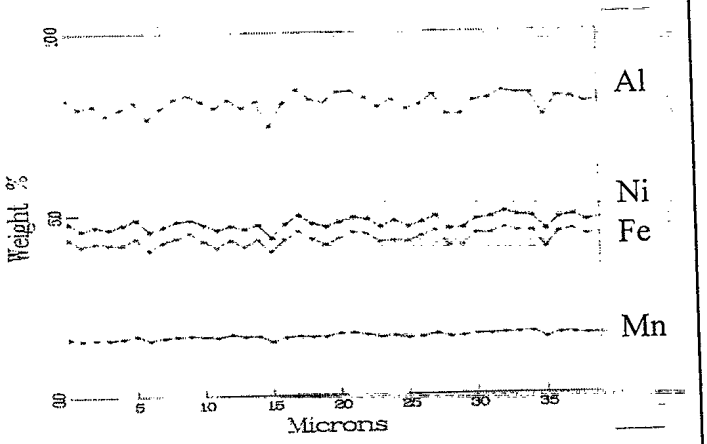
Widmanstatten α Structure

as-deposited weld metal region stage scan





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Fusion Zone Dendritic Region

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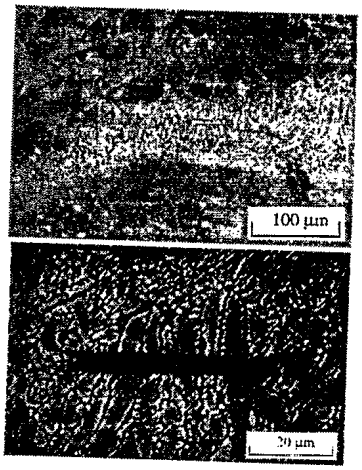
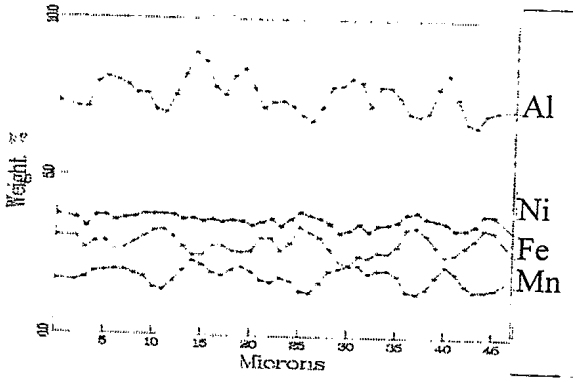
Fusion Zone Dendritic Region

- peaks correspond to dark interdendritic regions





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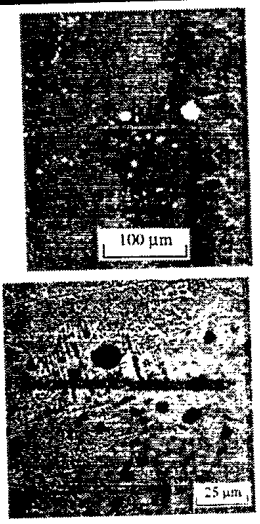
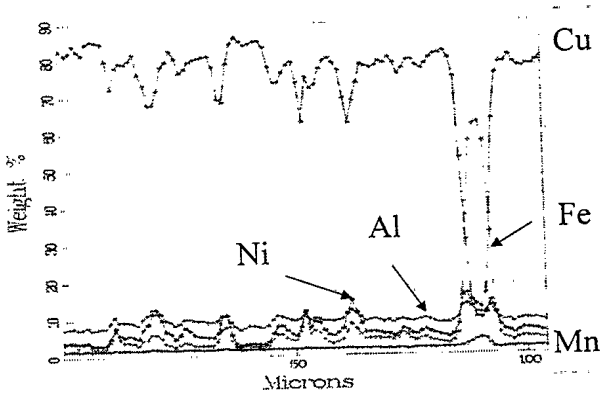
HAZ-Fusion Zone Region





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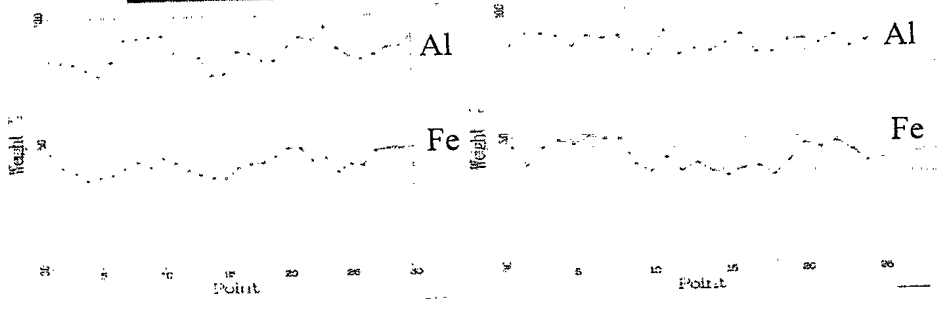
Beam Scans - 10 kV



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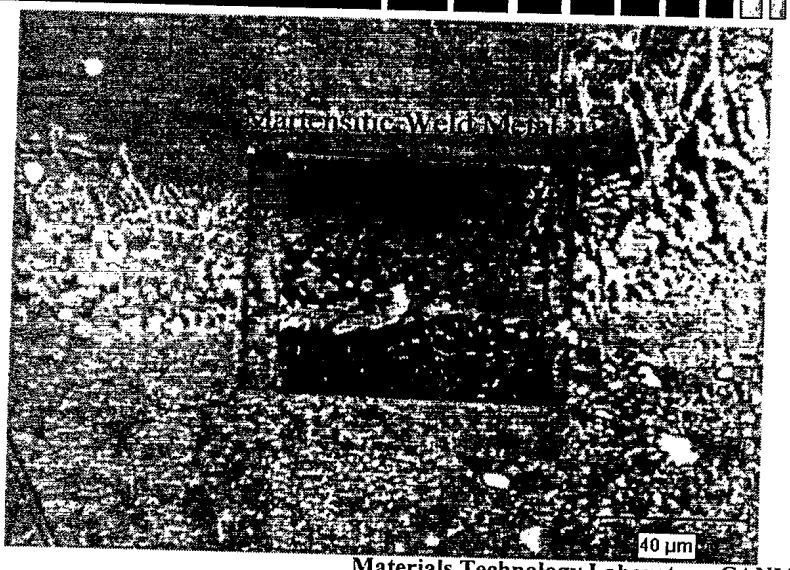
Location of X-ray Map Across Fusion line



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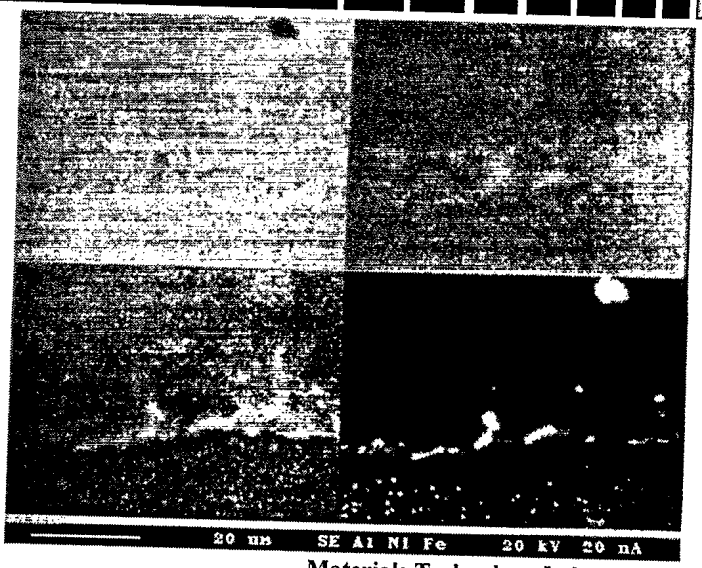
X-Ray Map near Fusion Line Interface



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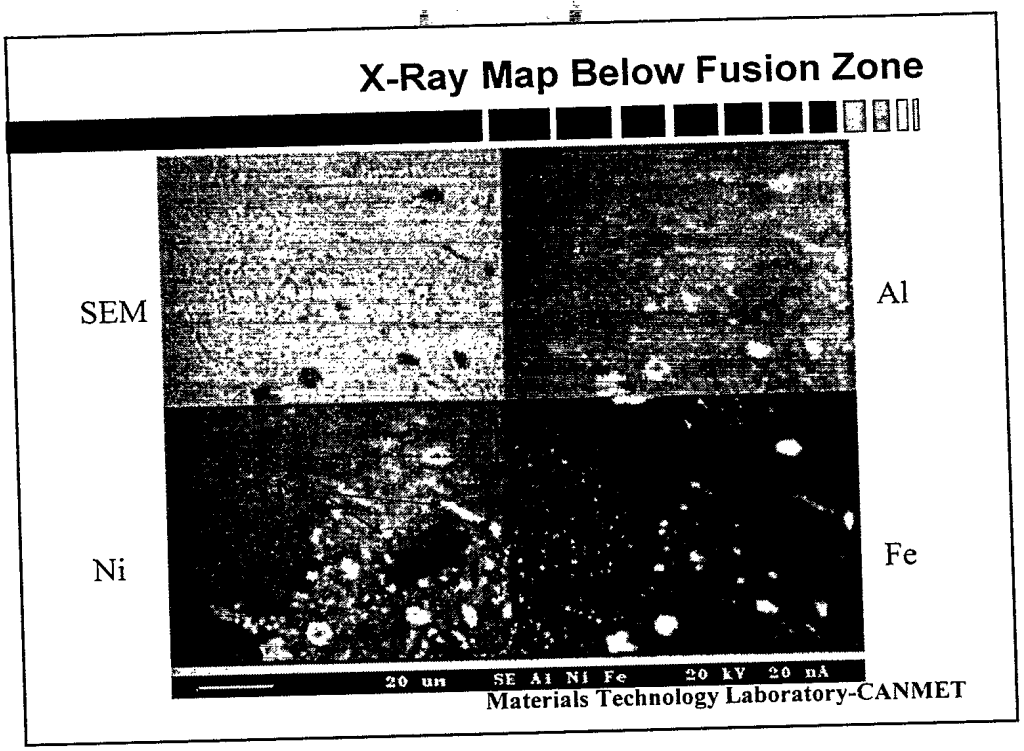
X-Ray Map Below Fusion Zone
SEM
Al
Ni
Fe
20 um SE Al Ni Fe 20 kV 20 nA
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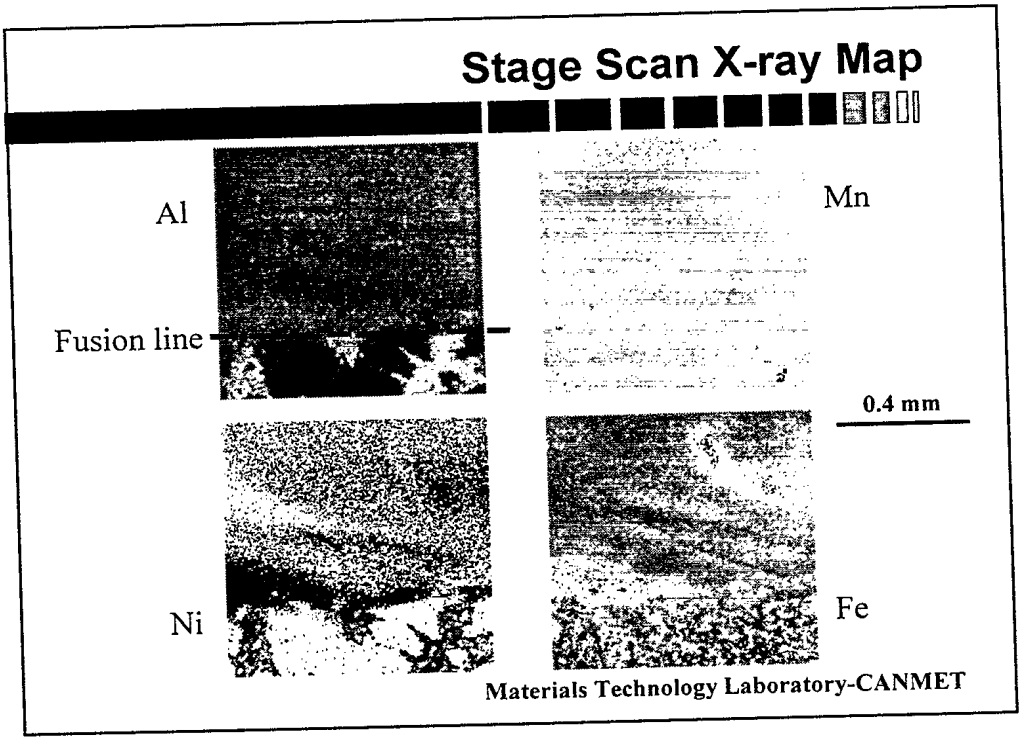
Stage Scan X-ray Map
Al
Mn
Fusion line
0.4 mm
Ni
Fe
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Summary - Weld Metal Compositions

Regions	Element wt %			
	Al	Ni	Fe	Mn
As-deposited martensite	7.9-8.8	4.5-5.0	4.0-4.5	1.5
As-deposited Widmanstatten α	8.1	4.7	4.4	1.6
Reheated Widmanstatten α	8.6	5.3	5.1	1.8
Dendritic Structure Area #1				
α	~6.8	3.8	3.3	~1.4
dark etching phase	8.3-8.9	3.6	2.5	2.3
Dendritic Structure Area #2				
α	7.5	3.6-4.0	3.4-4.5	1.2-1.6
dark etching phase	10-11	4.3-4.4	4.1-4.5	~1.8

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Summary- HAZ/Fusion Zone Compositions

Regions	Element wt %			
	Al	Ni	Fe	Mn
α matrix	7.3-8.1	3.2-4.0	2.2-4.6	1.6-1.8
eutectoid α + κ_{III}	10.8-11.0	7.8-12.0	7.0-11.5	1.9-2.0
κ_{II} particle in weld metal	11.0	9.6	62.7	4.3
weld metal martensite	9.4	7.6	5.7	1.5

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Summary - Base Metal Compositions

Regions	Element wt %			
	Al	Ni	Fe	Mn
α matrix	7.7	3.8	3.9	1.7
eutectoid α + κ_{II}	10.2	7.8	7.2	1.9
κ_{II} particle	5.5	4.9	65.5	9.6
α matrix	7.6	2.9	2.1	1.5

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Conclusions

- There are a wide range of microstructures present in the laser clad weldment studied, including martensite, Widmanstatten α, a dendritic structure and complex HAZ/base metal structures.
- Microprobe analyses show that there are significant compositional variations that correspond with the microstructural features on both micro- and macro- scales.

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