

NONLINEAR ULTRASONIC PARAMETERS TO LASER WELD QUALITY FOR SMALL MODULAR REACTOR

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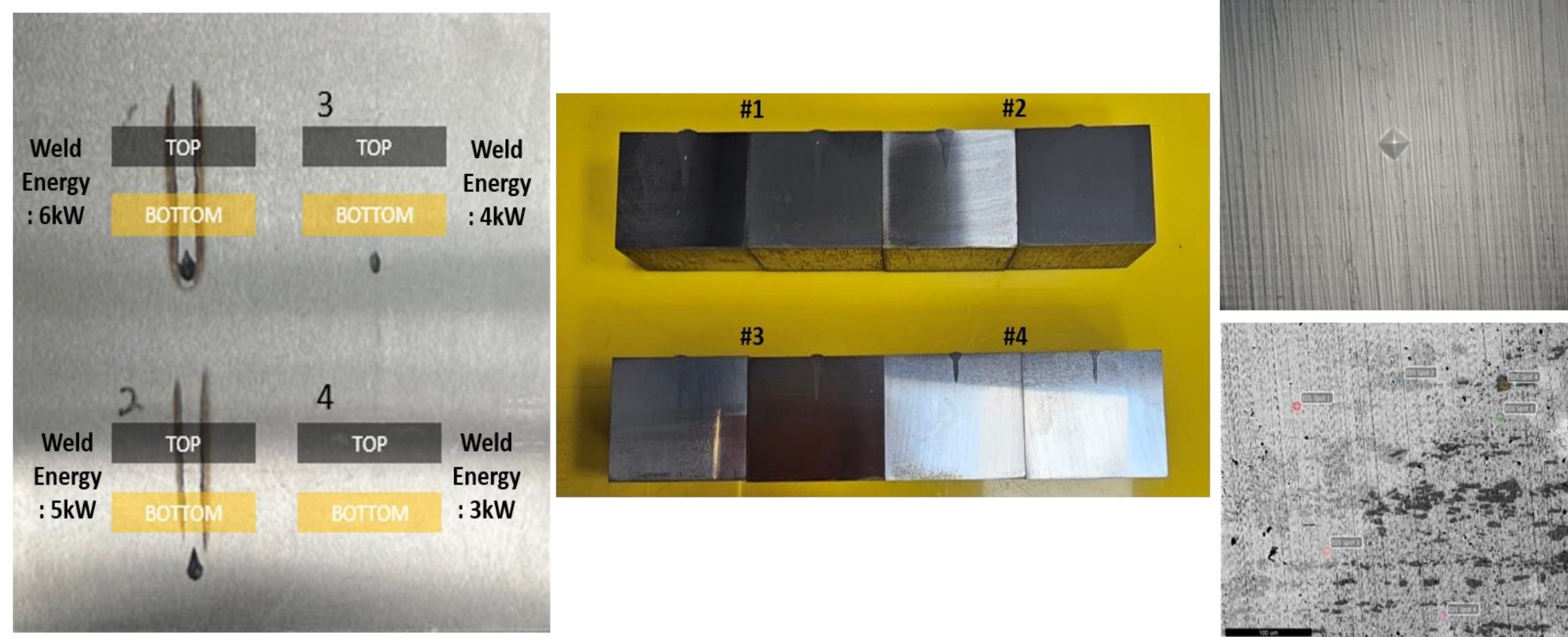
Introduction

- SMR manufacturing process of electron/laser weldings
- Conventional UT in mm scale cracks whereas nonlinear UT in microns
- How welding conditions change of nonlinear UT signals and parameters

Experimental

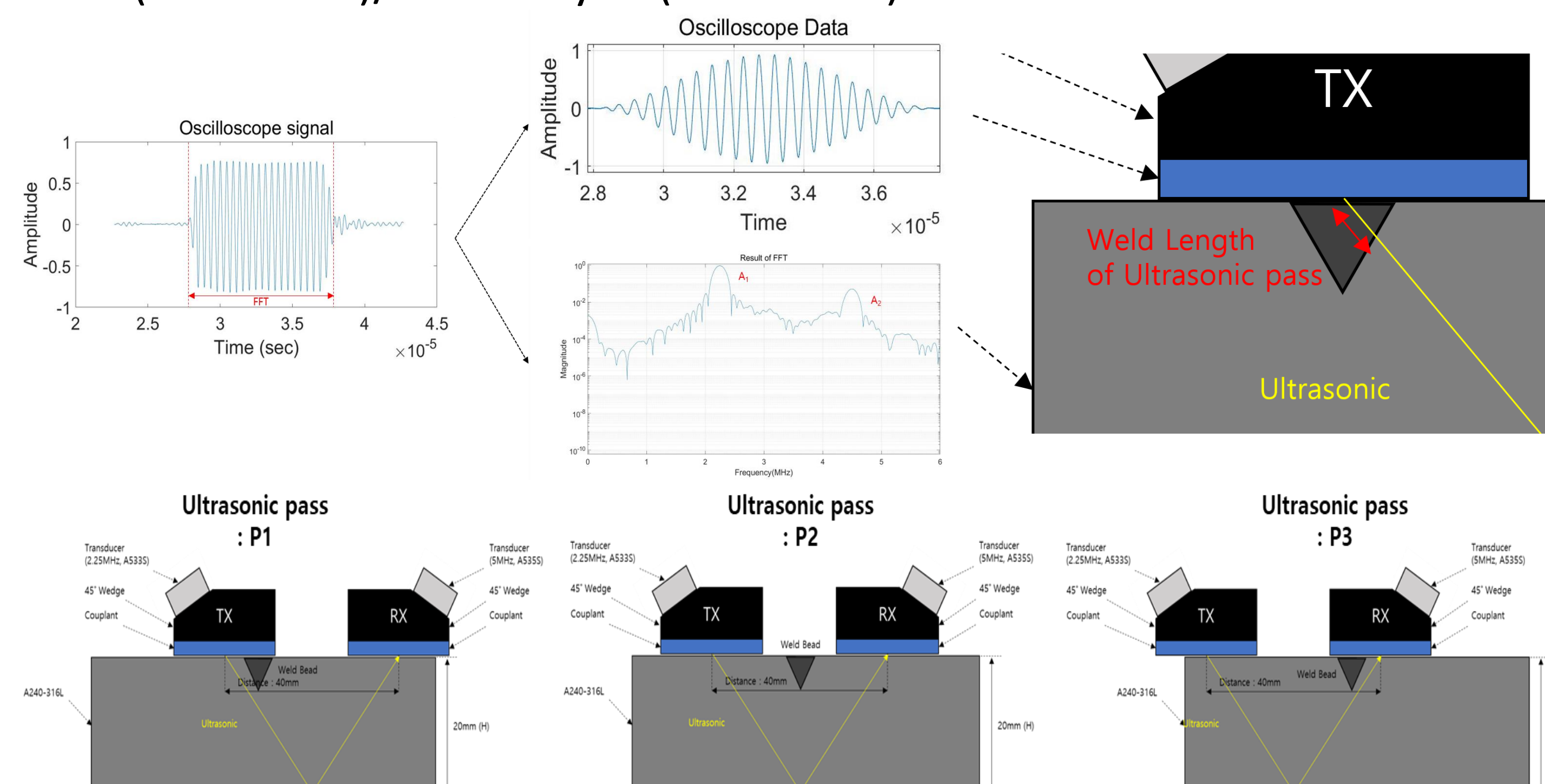
- Commercial 316L stainless steel hot- rolled plates (300 x 300 x 20T mm)
- Laser welding (IPG) of 1.8kW 200Hz 2ms top hat QCW (pulse type) mode with the speed of 1m/min (CNC movement)

Fe	Cr	Ni	Mo	Mn	Si	C	N	Cu	HV(HRBW)
Bal.	16.6	10.1	2.0	1.2	0.43	0.02	0.07	0.3	83.4-81.3



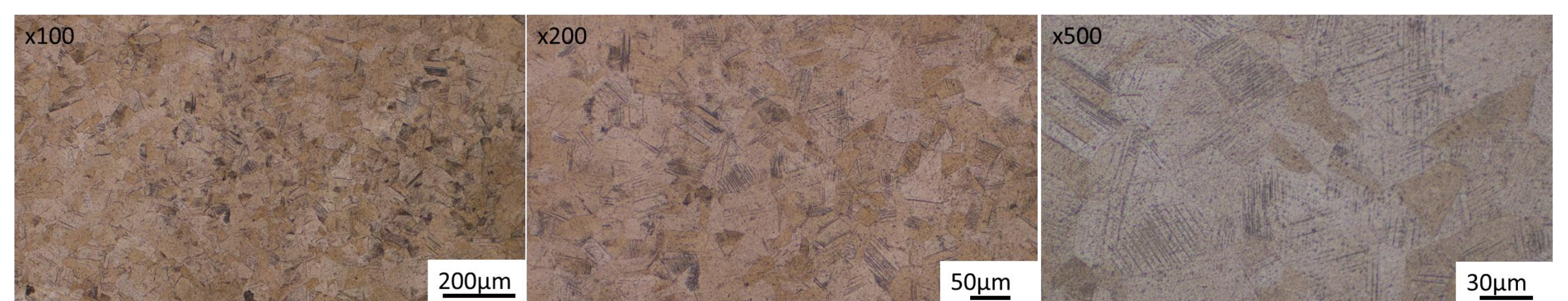
Chemical compositions and Pictures of 316L after laser welding and wire cut specimens for Vickers hardness and SE(EDAX point analysis) images

- Two 45° wedge angle 2.25MHz(Transmitter) and 5MHz(Receiver)
- Ultrasonic testing on P1&P3) bare-metal, and P2) weld zone
- SE(BSE-mode)/EDS analysis (JSM-IT800)

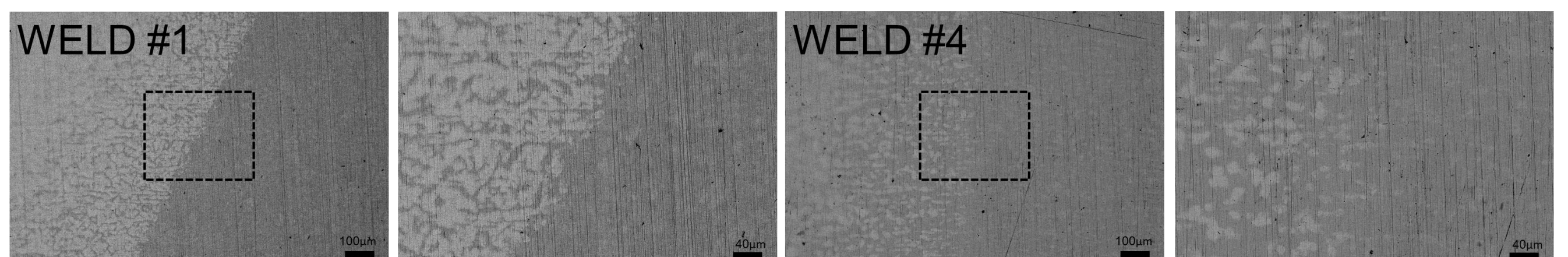


Result and Discussion

- Typical 316L with grain size of 20-40 μm
- hardness of base was lower than that of weld zone
- #4 (6kW) has higher hardness than #1 (3kW) due to the larger weld zone

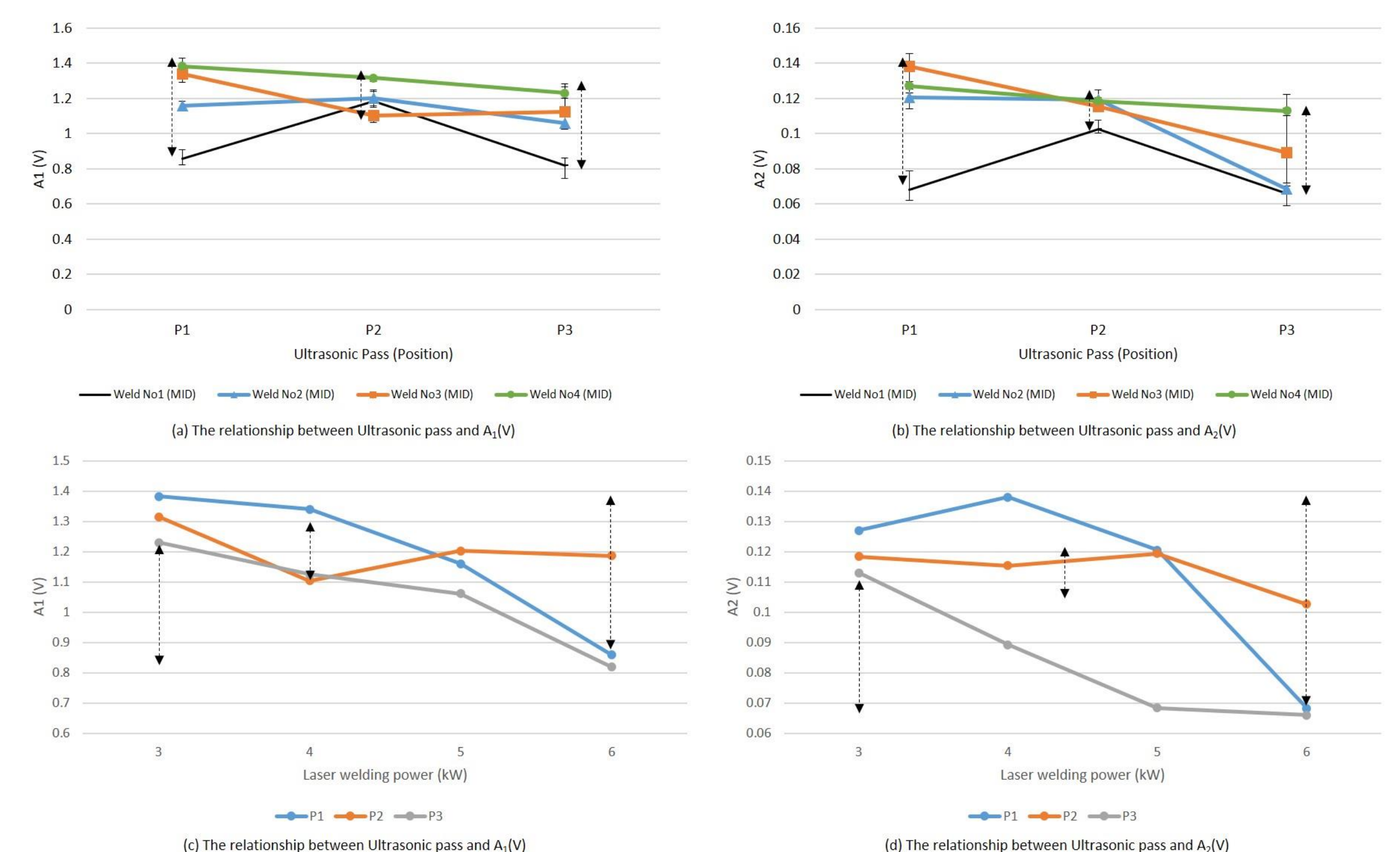


Hv0.5	Weld #1(6kW)	Weld #3(4kW)	Weld #4(3kW)
Base	207±8	225±17	244±21
Weld	425-476	596-782	437-453



Optical images of etched microstructure as-received 316L, HV, Cross-sectional SE(BSE) images of fusion weld and HAZ interface (#1 and #4)

- A linear relationship ($R^2 > 0.9$) between $A_1^2(V)$ and $A_2(V)$ was observed resulting in the constant β
- P1 and P3 showed a large difference in A_1 and A_2 values among the weld numbers(#1 to #4), whereas P2 showed similar A_1 and A_2 values
- A_2 values were low at the weld zone (position D, F) as compared to the base zone (position A, J)



METHOD A : A_1 and A_2 plots of a) and b) ultrasonic pass position, c) and d) laser welding power

Summary

- $A_1(v)$ was lower in the order of weld #4(3kW) to #1(6kW) reflecting the larger and deeper weld bead. The top and bottom side of bead showed different A_2 and β values owing to different features of the weldment.
- The larger weld size showed the smaller nonlinear parameter values while the weld defects resulted in decreasing the maximum signal amplitude