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Directed Energy Deposition of SS 316L/SiC Composites Using Coincident and Coaxial Wire-Powder Feeding

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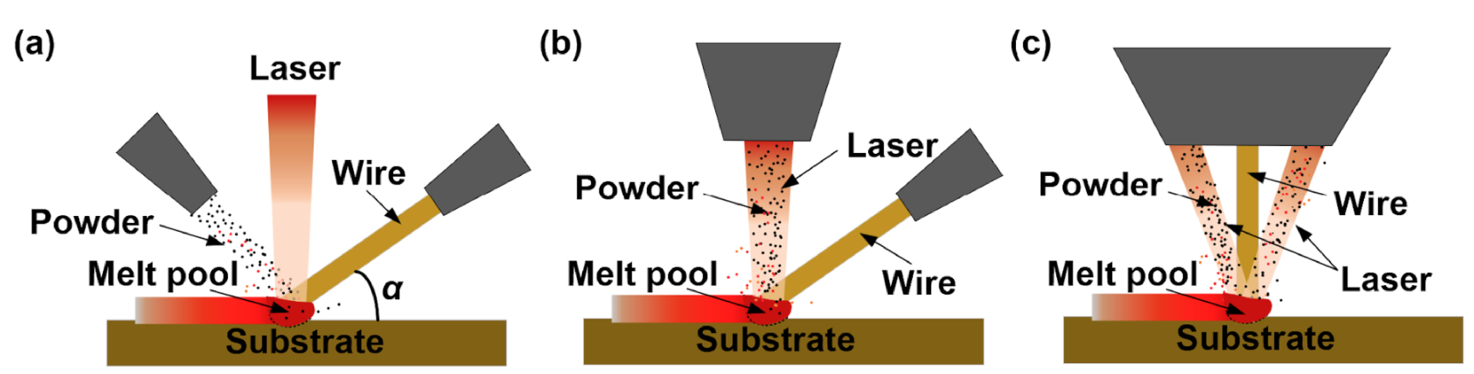
BACKGROUND

- During the WP-DED process, metal alloy wire and reinforcing particles are simultaneously fed from respective nozzles.



Lateral filler supply *Coaxial filler supply*

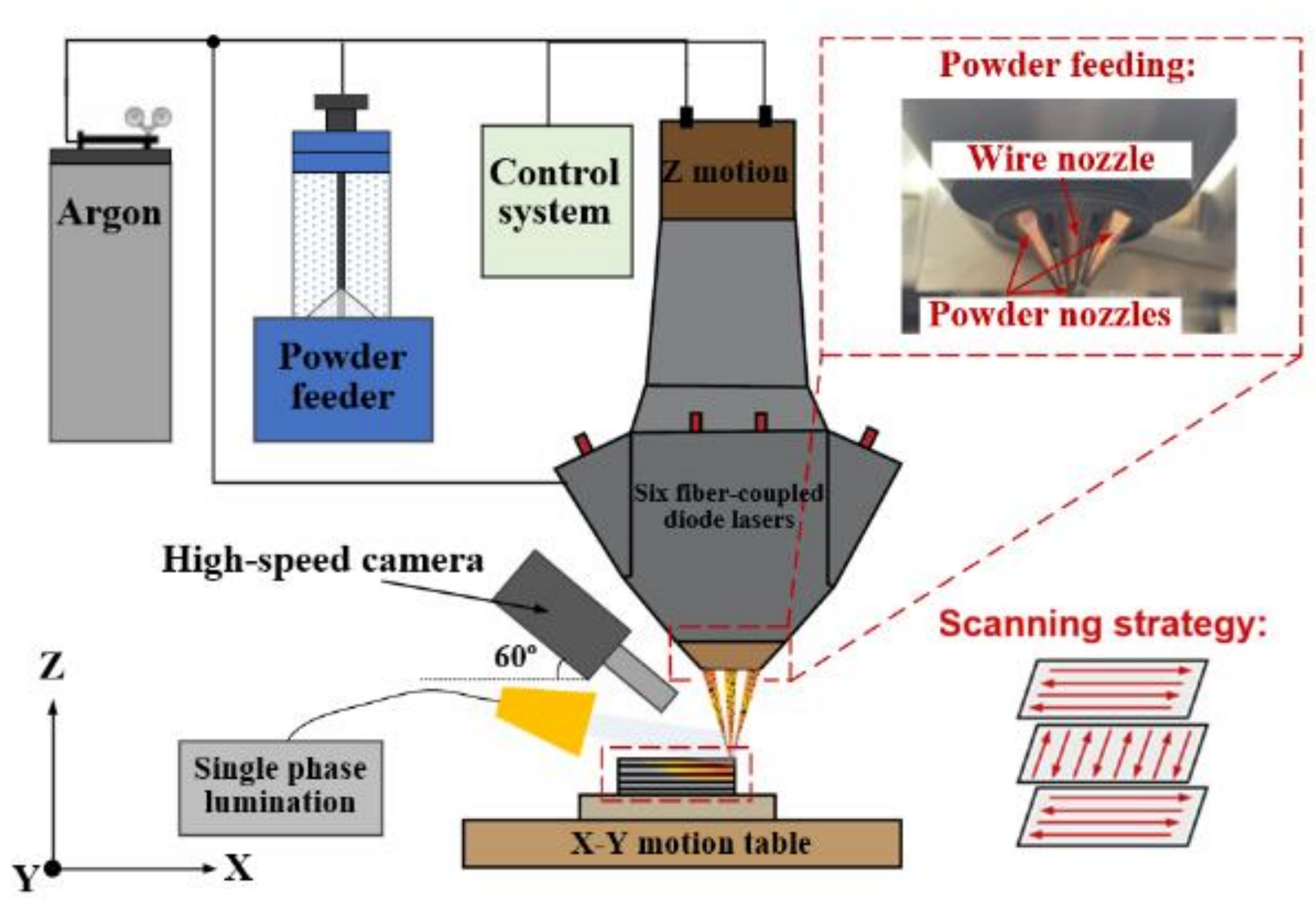
- Lateral wire-powder feeding as well as lateral and coaxial powder feeding are two existing methods for WP-DED of MMCs.
- Coaxial wire-powder fed DED (CWP-DED) is a directional-independent process to fabricate three-dimensional parts with designed structures. In addition, homogenous circular energy distribution around coaxial-fed wire and powder can be expected for uniform laser-filler interactions.

OBJECTIVE

- Investigate the feasibility of CWP-DED to fabricate MMCs.
- Unveal the effects of SiC contents on the defects, microstructure, and mechanical properties of as-built samples.
- Understand the underlying laser-matter interactions in CWP-DED of MMCs.

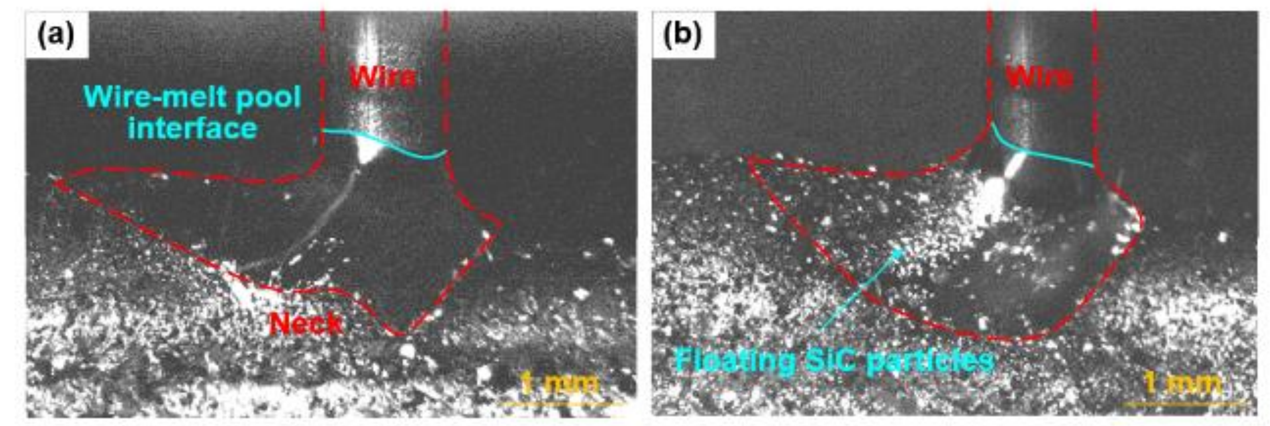
EXPERIMENTAL SETUP

- SS 316L wire and SiC powder were fed via the central nozzle and three "off-axis" nozzles, respectively.
- The fraction of SiC reinforcing particles can be easily determined by adjusting wire and powder feeding rates.
- Six single laser beams are arranged circumferentially around the feed nozzles to enable the stable deposition of dual fillers.
- A high-speed camera was used to capture the filler-melt pool with a record rate of 8,500 fps.



RESULTS AND DISCUSSION

Filler-melt pool interactions

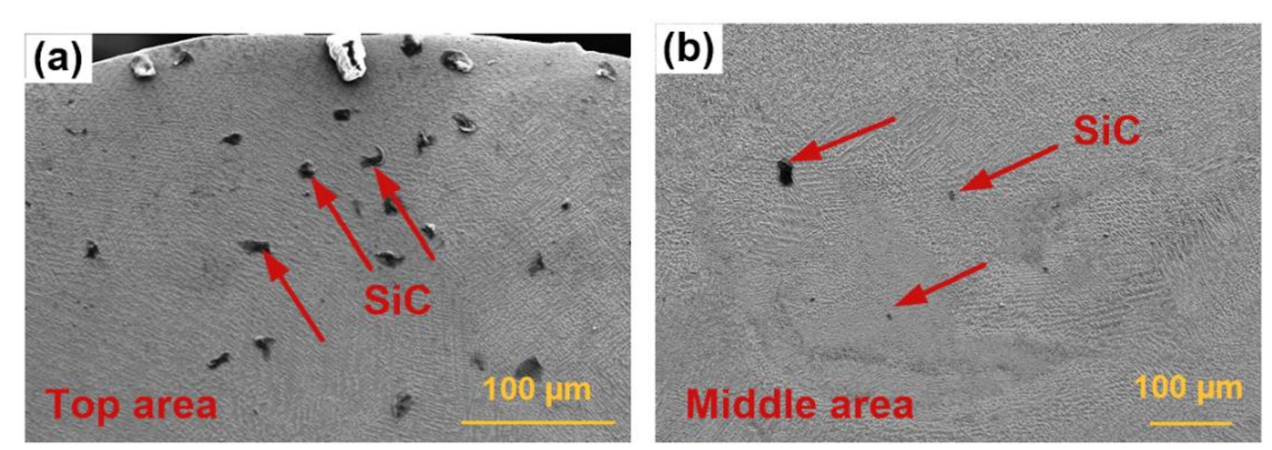


4 wt% SiC *8 wt% SiC*

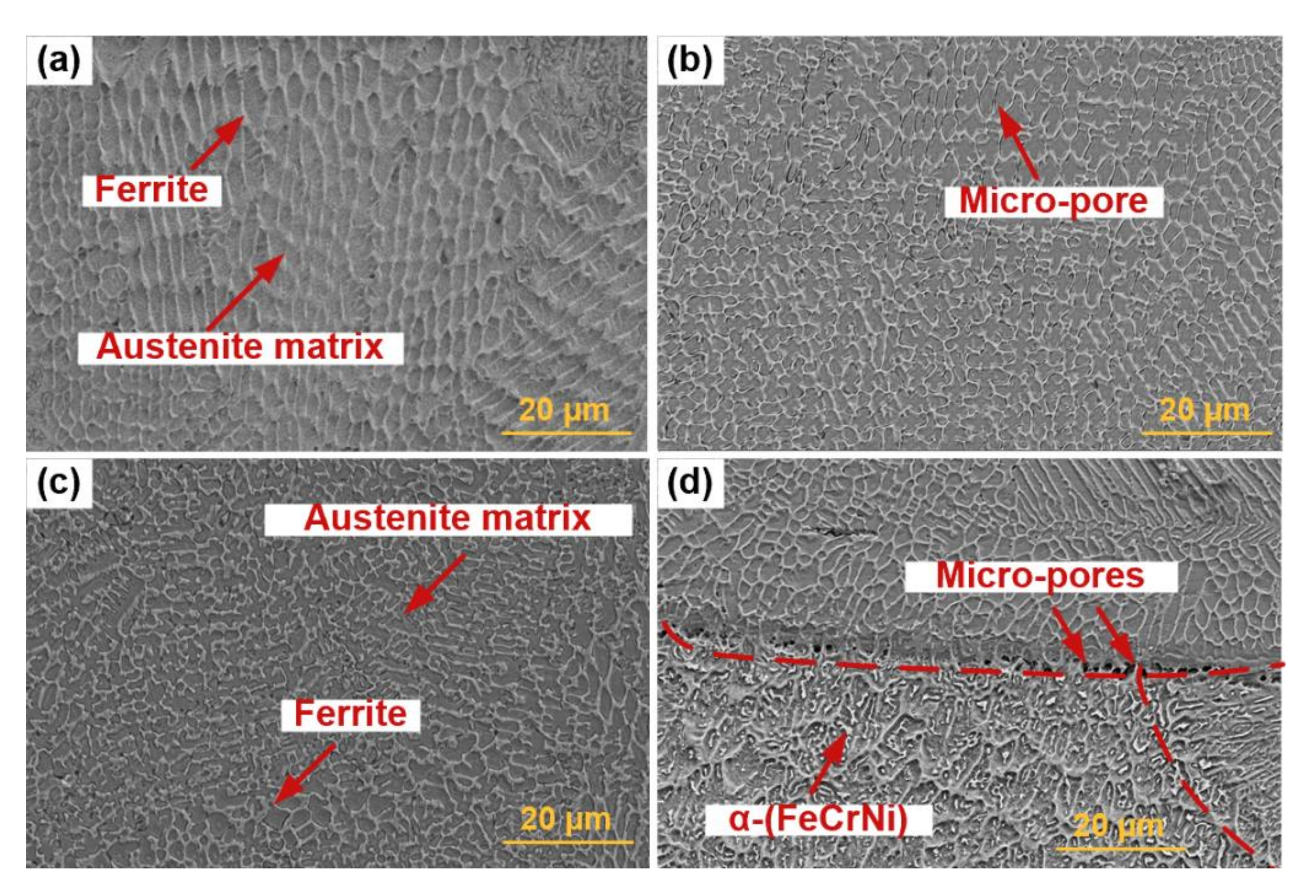
- The extruded wire is smoothly transferred into melt pool.
- A unique melt pool neck occurs at a low SiC content.
- Particle floating velocity in melt pool reduces with increasing the SiC content.

Microstructure

- **SiC distribution**

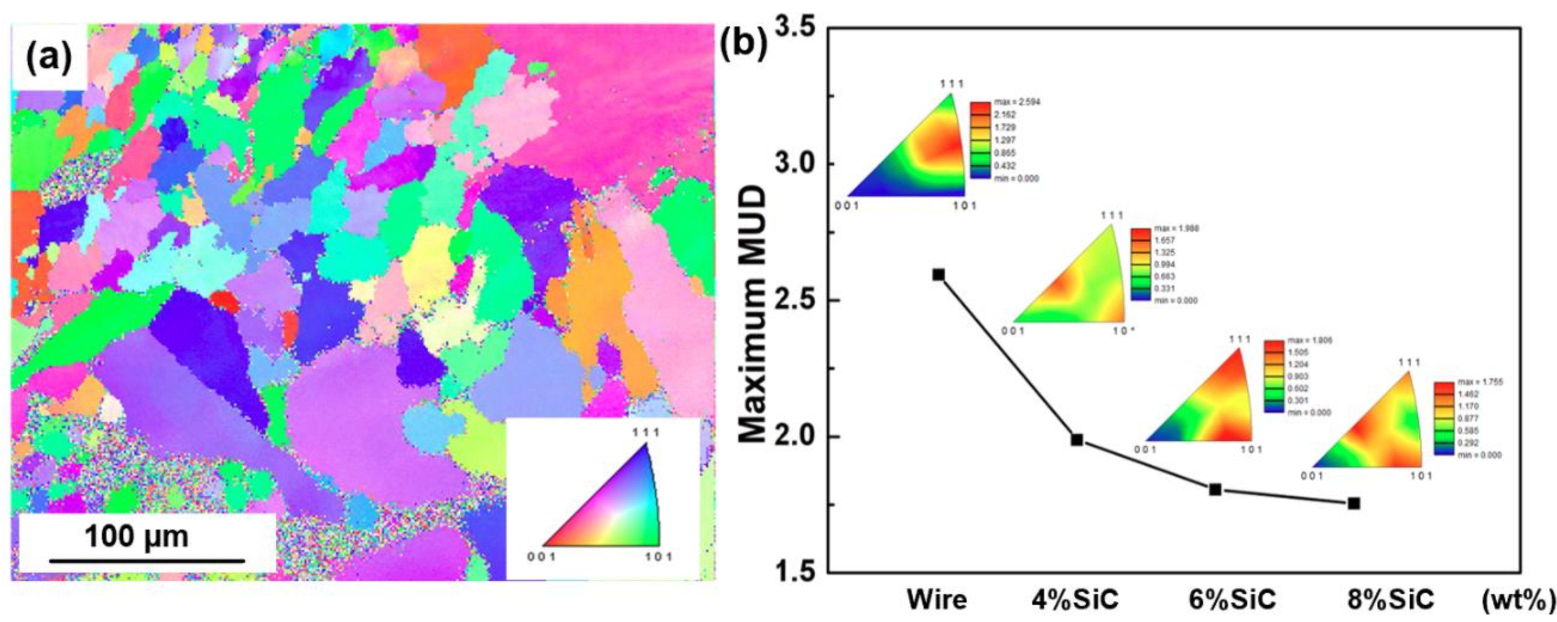


- **Microstructural evolution**



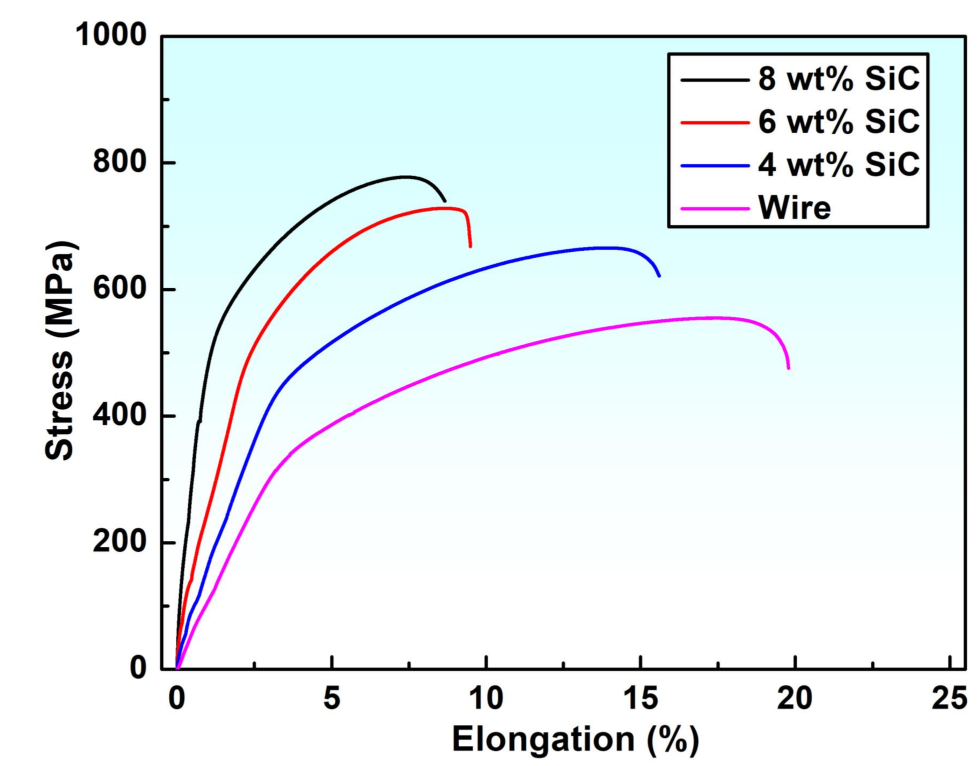
- Average grain size experiences a decrease from 4.3 µm to 3.3 µm with an increase in SiC.
- Grain boundaries are challenging to be distinguished at a high-level SiC content.
- At a high-level SiC content, α-(FeCrNi) phases precipitate within the γ-(FeCrNi) matrix.

Crystallographic orientation



- Grain texture weakens and even disappears with SiC content.
- Fraction of BCC phases increases with SiC content, suggesting more precipitation of α-(FeCrNi) phases.

Tensile properties



- Strengthening mechanisms: Dispersion strengthening, Grain boundary strengthening, Dislocation pinning by nanoscale SiC particles, and Phase strengthening

CONCLUSIONS

- Particle floating velocity in melt pool reduced with increasing the SiC content.
- With an increase in SiC content, the grains were refined due to a high cooling rate and dispersion of nano-scale SiC particles. In addition, more α-(FeCrNi) phases with BCC lattice structures precipitated from the γ-(FeCrNi) phase with FCC lattice structures.
- The increased SiC content enhanced the tensile strength but deteriorated the ductility of final parts.

ACKNOWLEDGEMENT

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