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Reinforcing L-PBF 316L Stainless Steel with BN: A Strategy for Enhanced Performance

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INTRODUCTION & AIM

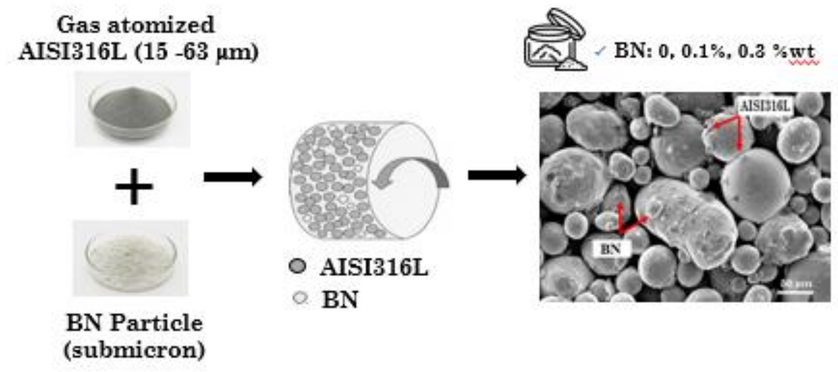
AISI316L is an austenitic stainless steel known for its excellent corrosion resistance, strength, ductility, and toughness, making it widely used in biomedical, automotive, chemical, and petrochemical industries. However, producing complex-shaped AISI316L components through conventional remains challenging due to limited design flexibility and material waste. Additive Manufacturing, particularly Laser Powder Bed Fusion (L-PBF), overcomes these limitations by building parts layer by layer directly from CAD models, offering high precision, excellent material efficiency, and the ability to fabricate intricate geometries. Despite these advantages, L-PBF fabricated AISI 316L parts often exhibit limited wear resistance and mechanical strength. To overcome these limitation, recent studies have explored reinforcement with various materials to form metal matrix composites (MMCs).

In this study, boron nitride (BN) is introduced as a stable ceramic reinforcement to develop a novel AISI 316L based MMC via L-PBF, aiming to improve the wear resistance and mechanical performance of additively manufactured components.

METHOD

Powder Preparation:

Gas-atomized AISI 316L powder was jar-milled with 0, 0.1, and 0.3 wt% BN for 12 hours to achieve uniform mixing and determine the optimal reinforcement content.

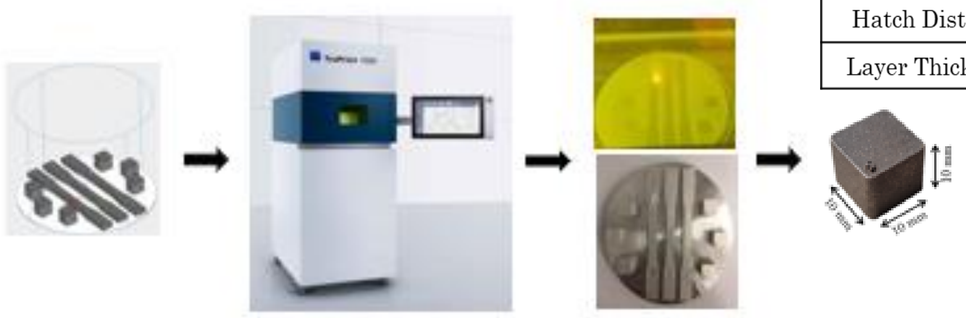


Printing process:

Laser Powder Bed Fusion (L-PBF) using a TruPrint 1000 (Trumpf)

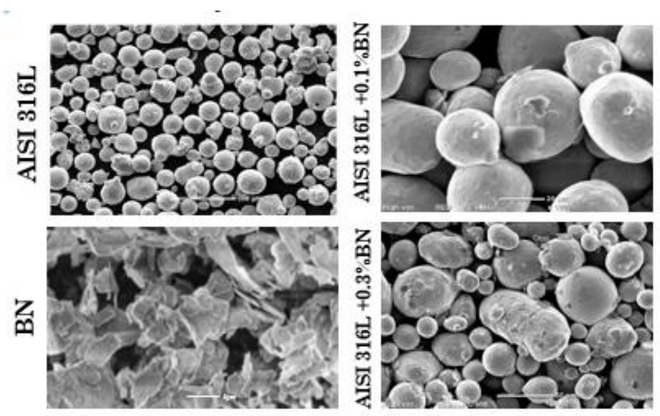
- ✓ Shielding gas: Argon
- ✓ Rotation angle: 67° / Layer

Process Parameter	Standard
Laser Power [W]	180
Laser Speed [mm/s]	500
Hatch Distance [mm]	0.01
Layer Thickness [mm]	0.03



Powder Analyses:

- ✓ A uniform distribution of BN particles
- ✓ BN particles adhered to AISI316L particles, forming satellite-like structures

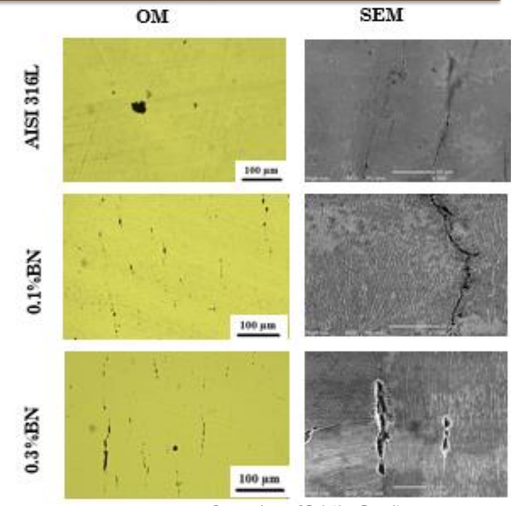


RESULTS & DISCUSSION

Defect Analysis

Increasing BN content:

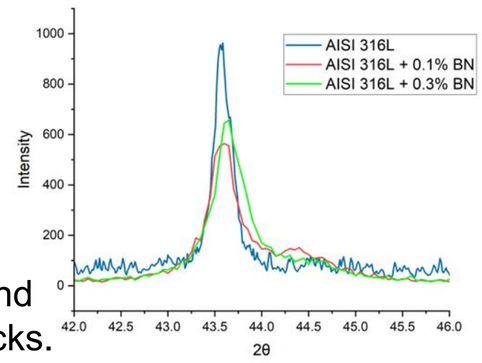
- ✓ Decreases processability
- ✓ Increases the crack density
- ✓ Cracks formed along the build direction and located at the grain boundaries

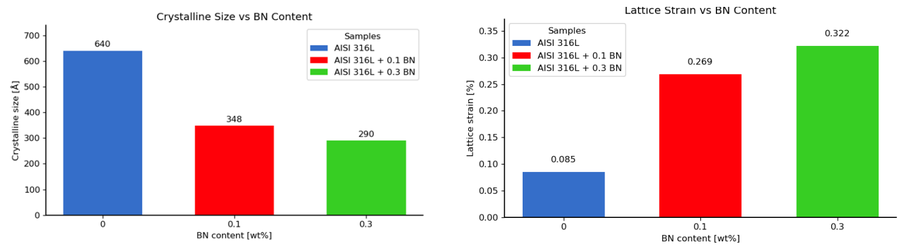


Phase Analysis

Higher BN content:

- ✓ Decreases crystalline size and increases lattice strain
- ✓ Enhancing material strength and hardness.
- ✓ Excessive BN may reduce ductility and induce residual stresses or microcracks.



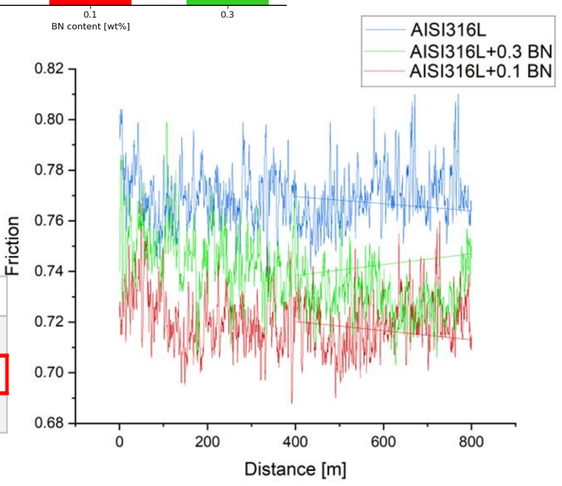


Wear Resistance Analysis

Increasing BN content :

- ✓ Decreases Friction Coefficient
- ✓ Improves Wear Resistance

Sample ID	Initial Weight (g)	Final Weight (g)	Weight Loss (g)
AISI316L	11.1125	11.0784	0.0341
AISI316L+ 0.1% BN	14.4155	14.4003	0.0152
AISI316L+ 0.3% BN	12.7155	12.6957	0.0198



CONCLUSION

The addition of BN to AISI 316L reduced processability and increased porosity and crack formation but led to finer grains and higher lattice strain, enhancing the material's mechanical performance. BN reinforcement improved hardness, stiffness, and wear resistance, with 0.3 wt% providing the highest stiffness and 0.1 wt% delivering the best tribological behavior.

FUTURE WORK/REFERENCES

Focus on optimizing the process and tuning L-PBF parameters to improve quality and performance.

1. Yin, Houshang, et al. "Carbon nanotube (CNT) reinforced 316L stainless steel composites made by laser powder bed fusion: Microstructure and wear response."
2. AlMangour, Bandar, et al. "Novel TiB2-reinforced 316L stainless steel nanocomposites with excellent room-and high-temperature yield strength developed by additive manufacturing." Composites Part B: Engineering 156 (2019)