Binder-jet additive manufactured metal matrix composites made by reactive sintering post-processing

Pablo Enrique, Norman Zhou, Ehsan Toyserkani
University of Waterloo, 200 University Ave W, Waterloo, Ontario N2L 3G1, Canada

1. Background

Metal matrix composites (MMCs) are materials with reinforcing phases that demonstrate low densities, high strength-to-weight ratios, excellent high temperature performance, fatigue resistance and wear resistance.

Manufacturing of MMCs face several challenges, including:

- Inhomogeneous distribution of the reinforcing phase
- Low quality reinforcement-matrix interface bonding
- Machining difficulties due to the combination of ductile matrix and hard reinforcing phase

2. Objective

Binder-jet additive manufacturing (BJAM) allows for the near net shape printing of parts. Combined with a *reactive sintering* process, parts can be made to achieve:

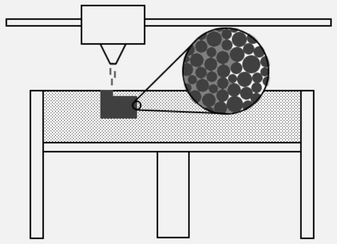
- Well distributed reinforcing phases and good interface bonding for improved wear resistance
- The desired final dimensions without machining

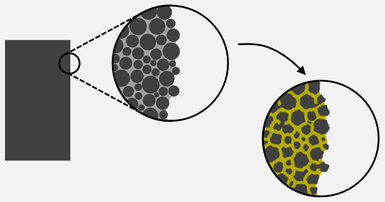
The wear resistance of reinforced BJAM MMC is compared to unreinforced BJAM Inconel 625, to evaluate material performance and potential use in high wear applications.

3. Materials & Methods

After printing, BJAM parts are composed of powders held together by a glue-like binder.

Inconel 625 (NiCrMoFeNb) powder and Zb60 binder was used.

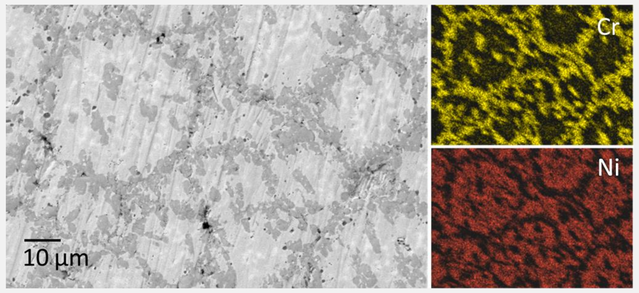




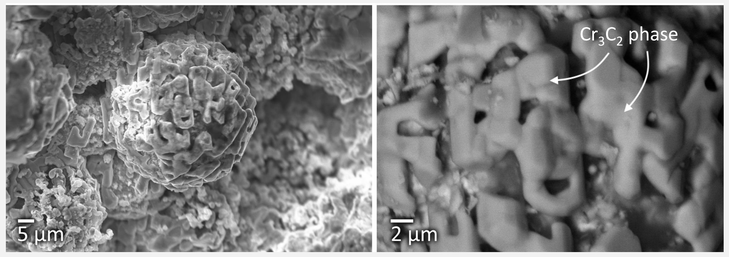
Printed parts were sintered at elevated temperatures so that a chemical reaction occurs between the powders and the binder.

4. Results

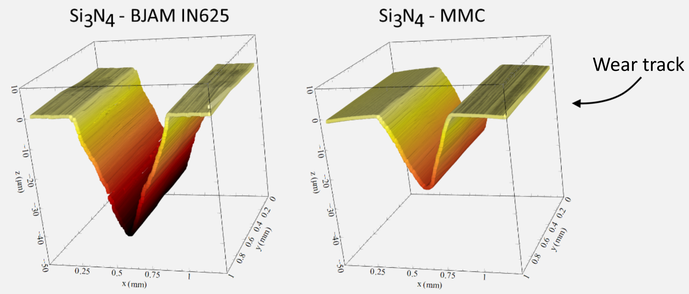
Reactive sintering of BJAM Inconel 625 parts forms a reinforcing Cr_3C_2 shell surrounding a nickel alloy core.



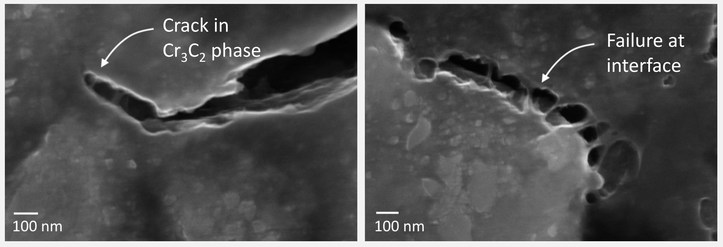
The interconnected 3D structure of the reinforcing carbide is better observed by viewing the surface of the part. This structure suggests that the MMC is co-continuous, with an interconnected metal and reinforcing phase.



Linear wear testing against a Si_3N_4 pin shows a 3 times improvement in wear resistance of the BJAM MMC when compared to unreinforced BJAM Inconel 625.



The wear tested surface shows initiation of cracks in the Cr_3C_2 phase and failure occurring due to crack propagation via pore coalescence along the Cr_3C_2-matrix interface.



5. Conclusions

The use of binder-jet additive manufacturing and reactive sintering post-processing to form co-continuous ceramic reinforced metal matrix composites was demonstrated.

- During reactive sintering of Inconel 625, Cr diffuses to the powder particle surface and reacts with C from the decomposed binder.
- The resulting Cr_3C_2 phase shows good matrix interface characteristics and a 3 times improvement in the wear resistance.

6. Acknowledgements

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