3D Printing of Bioinspired Damage-Tolerant Ceramic Matrix Composite

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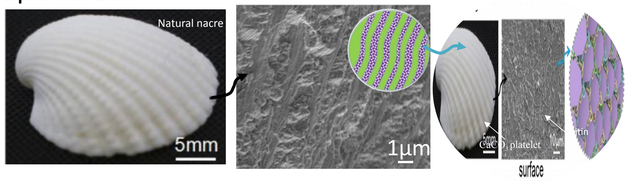
1. Introduction

The usage of polymer and polymer-based composites as functional materials is often restricted to applications in non-harsh environments, due to their low melting point, poor mechanical flexibility, and corrosiveness. The functional composite for future applications, however, demands material with superior properties in terms of density, electrical conductivity, thermal stability, and corrosion resistance. Ceramic matrix composites (CMCs), a group of material with competitive specifications, has therefore drawn extensive interests over other types of materials for advanced aerospace applications. However, ***a major challenge with current CMCs is to achieve superior mechanical flexibility while maintaining low material consumption***. Nacre, composed of natural ceramic composites, exhibits such multifunctional integration inherently because of its sophisticated hierarchical brick-and-mortar (BM) architecture ranging from nanoscopic to macroscopic levels.

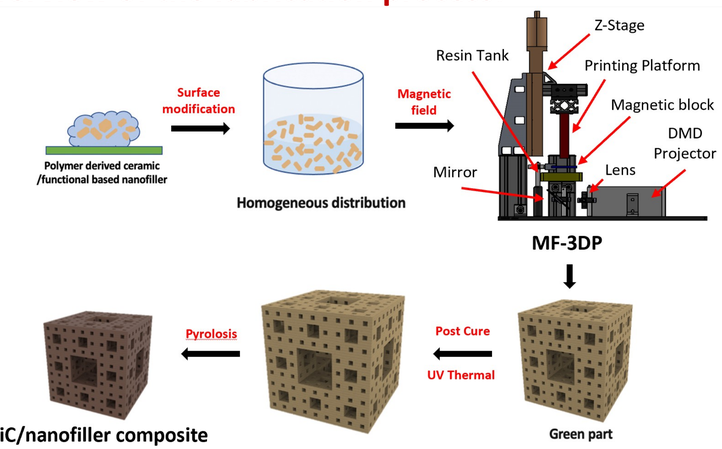


2. Abstract

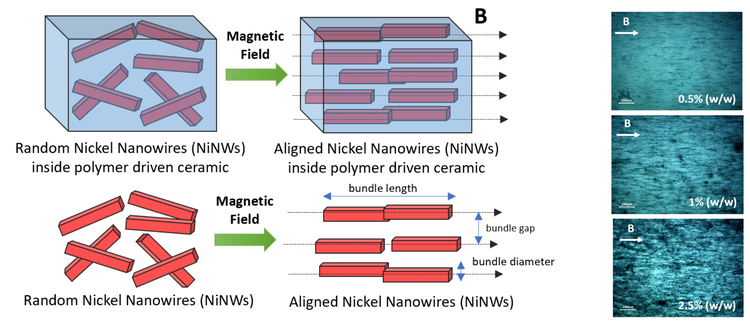
In nature, limpet teeth displays properties of flexibility and toughness that prevents against high structural damage. In this proposed research, limpet teeth inspired CMCs are fabricated via magnetic field assisted nanocomposite printing for enhanced mechanical properties. Nickel nanowires in liquid polymer resin are placed under a magnetic field to form bioinspired rostrum 3D architectures and silicon carbide (SiC) CMC is formed through pyrolysis and sintering processes. These mechanical properties are studied for various applications.

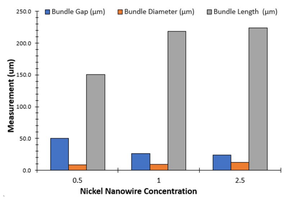
3. Result and Discussion

Overview of the fabrication process:



Magnetic Field Alignment

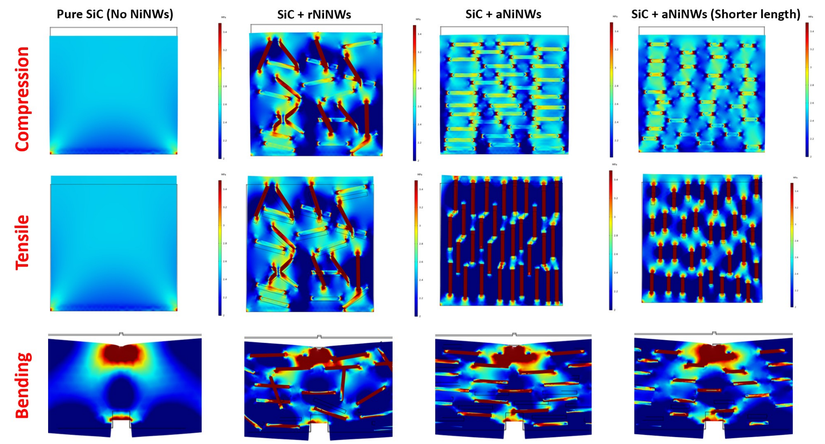




After a magnetic field is introduced to the polymer driven ceramic, the Nickel Nanowires (NiNWs) are aligned. As concentrations of NiNWs are increased, the bundle diameter and length increase as the bundle gap decreases.

Simulation of CMCs

The simulations for compression, tensile and bending were ran using 207 GPa (Young's modulus) for Nickel with 0.305 Poisson ratio with SiC having 50 GPa (Young's modulus) and 0.14 Poisson ratio. Applied force was -1000 N



4. Future Work

1. Test printed materials on mechanical properties
2. Further evaluate thermal and electrical properties of material
3. Execute and evaluate an Emi shielding study
4. Print a demonstration part as an example of application

Acknowledgments

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Reference: 1. Low, I., 2018. Advances in ceramic matrix composites. Advances in Ceramic Matrix Composites.
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