Bending and Radial Mechanical Behavior of Deep-sea Sponge Inspired Tubular Metamaterials

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Abstract (in 12 Pt Arial Font)

The COVID-19 pandemic has underscored the significance of nasal swabs in diagnosing respiratory infections, necessitating the exploration of efficient manufacturing methods. The motivation of this study stems from the need for improved manufacturing speed and mechanical properties for medical devices. To achieve this, the study introduces 3D printed architected materials tip to traditional Nasal Swaps, aiming to create a better diagnostic tool with enhanced mechanical properties. The novelty of this study lies in the incorporation of bioinspired structural elements into Nasal Swaps, drawing inspiration from the sea sponge's skeletal lattice. By leveraging the sea sponge's evolutionary trial-and-error process, the study aims to enhance the bending and radial compression properties of Nasal Swaps. This bioinspired approach offers a novel perspective on improving the mechanical performance of diagnostic tools. To assess the mechanical benefits of the sponge-inspired architecture, we performed 3-point bending and radial compression testing, comparing the performance of the sponge-inspired structure with three traditional designs. Our results demonstrate significant improvements in mechanical properties. Notably, the sponge-inspired design exhibits enhanced flexibility, with stiffness approximately 2 times that of conventional tubular designs. Moreover, the strength and toughness of the sponge-inspired design are approximately 3 and 4 times greater, respectively, compared to traditional designs. The exceptional bending behavior of the sponge-inspired design makes it highly suitable for applications requiring a high degree of flexibility. Additionally, the sponge-inspired design demonstrates superior resistance to radial loading, thanks to its reinforcement system comprising interconnected channels and struts. Our experiments reveal that the sponge-inspired design exhibits approximately 1.3 times greater radial compression stiffness than unreinforced counterparts. Beyond COVID-19 testing, the structural Nasal Swaps developed in this study have broader applications in various fields. Their enhanced mechanical properties make them suitable for applications such as respiratory infection diagnostics in general healthcare settings, surveillance and monitoring of airborne diseases, rapid point-of-care testing for infectious diseases, and environmental sampling for air quality assessment. The improved flexibility, stiffness, strength, and toughness contribute to the reliability and efficiency of these diagnostic tools across multiple contexts.

Biography of Presenter (in 12 Pt Ariel Font)

Zhennan Zhang is a Ph.D. candidate in Dr. Yanyu Chen’s group at the University of Louisville. He has been working as a research assistant since 2020 and has made substantial contributions to multiple research projects funded by the NSF. His passion for additive manufacturing and his technical abilities have led him to explore innovative metamaterials, publishing 14 articles in peer-reviewed journals. His multidisciplinary background and extensive research experience have transformed him into an enthusiastic mechanical engineer.