Programmable Surface Dimpling for Aerodynamic Textile Metamaterials

David Farrell*[1], Connor Mccann[1], Antonio Elia Forte[2], Conor J. Walsh[1], and Katia Bertoldi[1]

[1]Harvard John A. Paulson School of Engineering and Applied Sciences – United States
[2]King's College London – United Kingdom

Abstract

For high-speed sports, marginal differences in air resistance can have a compounding impact over time, making aerodynamics a critical factor in determining competitive success. Traditional textiles used in athletic apparel are characterized by fixed surface roughness and static aerodynamic properties, overlooking dynamic velocity profiles and varying environmental conditions. Here, we introduce textile metamaterials designed to promote and actively control mesoscale dimples on worn textiles. Our textile metamaterial consists of a stiff woven fabric bonded to a spandex knit. Guided by Finite Element simulations, we demonstrate that by varying the architecture of the woven fabric, we can significantly alter the shape, location, and depth of the dimples on the worn textile, as well as their evolution under applied deformation. Notably, by optimizing the dimples, we can selectively modulate the drag of a textile-wrapped cylindrical shape. More importantly, we show that by controlling the applied deformation, we can actively tune the dimples to maintain minimal drag force under varying wind speeds. These advancements open the door to a new generation of adaptable, aerodynamic textiles.

*Speaker