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Super-hydrophobics Surface for Skin Friction Drag Reduction in High Reynolds Number Turbulent Flow[1]

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Since Onda et al. (1996) reported the development of super-hydrophobic surfaces (SHS) with a fractal topology, there has been significant world-wide activity in research related to the physics, material science, and manufacture of a wide variety of SHSs. Liquids undergoing laminar flow over SHSs may develop a Cassie-Baxter state at the flow boundary, and the presence of the gas pockets between rough surface asperities leads to a reduction in the shear stress compared to that of a smooth solid boundary, especially in flow channels where the slip length is on the order of the channel dimension (e.g. micro-fluidic devices). Yet, SHSs influence on fully developed turbulent boundary layers (TBL) is unclear. In order to develop SHSs that will reduce skin friction drag at high Reynolds numbers ($Re \geq 10^5$), our multi-university research group conducted a five-year effort focusing on five areas: (1) creation of optimized SHSs for high Reynolds number - we developed methodologies to manufacture specific SHSs with the desired surface energy and topology for the experimental examination of TBL modification at high Reynolds numbers; (2) examination of the interaction of near-wall flows with micro-scale surface gas pockets; (3) examination of the turbulence modification of micro-structured SHSs by TBL flow; (4) development of SHSs for passive and active gas replenishment to develop and maintain the Cassie-Baxter condition; and (5) experimental validation of SHS drag reduction at high Reynolds Numbers. This talk will present an overall summary of the efforts results and conclusions.

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