Novel Hydrophobic/Hydrophilic Macro-Patterns for Enhancing Water Vapor Condensation

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Condensation plays an important role in thermal desalination, environmental control, and power generation processes with a combined global market of $300 billion per year. Hydrophobic surfaces induce drop-wise condensation which has 10-20 times higher efficiency than film-wise condensation encountered in conventional systems. Nanoscale hydrophobic surface patterns have been reported, but they are costly and fragile. The goal of this project was to develop low-cost hydro-phobic/philic macro-patterns to enhance the rate of water condensation. The commercial hydrophobic coating selected for this project had a contact angle of 120°. Prefatory tests showed that the aluminum with the hydrophobic coating condensed 4% more water than the untreated hydrophilic surface (control). The performance was limited by the surface coverage of pinned, slow growing Wenzel droplets. To overcome this problem, surfaces with hydro-phobic/philic patterns were explored. 10 stencils were prepared using a 3D printer and used to apply the hydrophobic patterns. Test setups were developed to collect water condensation data. The patterns used for the final tests consisted of vertical, alternating hydro-phobic/philic stripes. The best performing pattern condensed 52% more water than the control, and hence reducing the heat transfer surface area requirements. The optimum width of the hydrophilic stripe appeared to match the droplet detachment diameter reported in literature. The experimental heat transfer coefficient for the macro-patterns was comparable to those reported by leading researchers for nano/micro-scale patterned surfaces. This method could improve the effectiveness of water production and utilization while providing 33% savings in heat transfer equipment.

Awards Won:

Third Award of $1,000