Simultaneous Dropwise/Filmwise Condensation on Hydrophilic Surfaces

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Although current research in condensation heat transfer focuses on the use of superhydrophobic surfaces to promote dropwise condensation, which has greater heat transfer performance than filmwise condensation, the need for a hydrophobic coating makes this surfaces unpractical in harsh environments. Hence, in this research effort we look into the effect of structural effects on a hydrophilic configuration aiming for the design of surfaces with enhanced condensation heat transfer performance without the need for a hydrophobic coating. On surfaces with a fixed micropillar aspect ratio, the spacing between pillars was found to have a strong impact on the condensation dynamics and on the final morphology of the condensate. In the case of micropillars with large spacing between pillars, the final condensation behaviour reported is that of filmwise where the condensate eventually floods the surface. On the other hand, as the spacing between micropillars is decreased, the condensate is constrained by the microstructure geometry and the rise of the condensate above the micropillars is not thermodynamically favourable. Then condensation takes place as filmwise condensation between the microstructures while continuous nucleation, growth and departure of micrometre droplets is observed at the micropillars tops. A simple heat transfer model is then proposed to demonstrate the greater heat transfer performance of this novel simultaneous dropwise/filwise condensation mode when compared to solely filmwise condensation. Furthermore, on a micropillar configuration with the very same aspect ratio and the same spacing between pillars, we found that we could also induce a different condensation behaviour by varying the orientation of the nano-roughness decorating the sides of the pillars. To conclude, we propose future guidelines for the design of surfaces with enhanced heat transfer performance without the assistance of a hydrophobic coating.