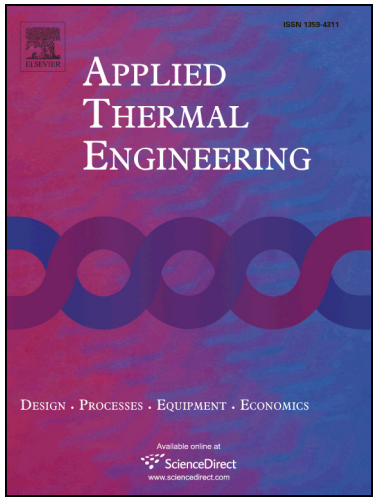

Frost Spreading on Microscale Wettability/Morphology Patterned Surfaces

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Frost Spreading on Microscale Wettability/Morphology Patterned Surfaces

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Abstract:

Frost on a solid surface spreads essentially via building up ice bridges between condensed droplets. Modulation of condensate droplet distributions is thus an effective approach to control frost spreading. Here, we investigate the effects of both surface wettability and morphological patterns on the frost spreading velocity for various substrate surface temperatures. Our experimental results showed that the morphological patterned surfaces drastically retard frost spreading while the effect of the wettability patterned surfaces is not significant. The frost spreading velocity increases with decreasing substrate temperature on the smooth surfaces and the wettability patterned surfaces. The morphology patterned surface effectively resists frost spreading over a wide range of subcooled temperatures. A simple model is proposed to elaborate the effects of wettability, morphology, and temperature on the frost spreading velocity and the model is found to be in reasonable agreement with our experiments. Additionally, microphotography reveals ice bridging regimes in different cases. Our findings facilitate understanding of the frost spreading dynamics which can lead to the novel designs of frost-free surfaces.

Keywords: Frost spreading; Morphological patterns; Wettability patterns; Substrate temperature; Ice bridging.

1. Introduction

Condensate frosting may be considered as one of the most pervasive types of ice that is associated with numerous industrial applications, such as air conditioning, refrigeration, heat pump, and cryogenics systems [1-4]. Many detrimental effects result from the frost accretion. Particularly, heat exchanger performance in such systems deteriorates drastically due to additional thermal resistance induced by the