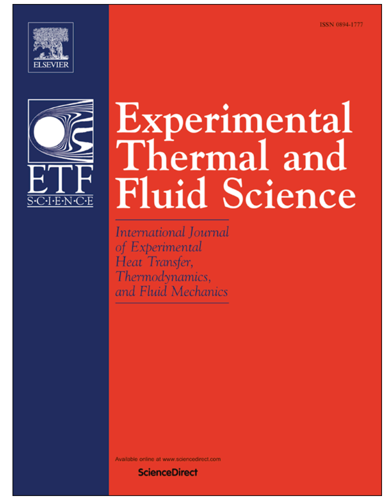

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Nucleate boiling on ultra-smooth surfaces: explosive incipience and homogeneous density of nucleation sites

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ABSTRACT
Pool boiling heat transfer characteristics in saturation conditions are investigated on rough and ultra-smooth surfaces of several aluminum samples, acetone being the working fluid. The topography of the surfaces is analyzed with a confocal microscope: the samples are methodically scanned in order to record the height or the depth of each point of the surface with respect to its mean altitude. This analysis enables to characterize both the mean roughness of the sample but also the presence of significant imperfections due to the polishing process. Depending on the characteristics of the surfaces, different types of boiling incipience - from gradual to explosive - are observed using a high speed camera. When the heat flux is gradually decreased following boiling incipience on an ultra-smooth surface, nucleate boiling subsists for very small heat fluxes, leading to a homogeneous distribution of very small bubbles on the entire surface. On the contrary, in the same conditions, rough surfaces or ultra-smooth surfaces with imperfections are not able to sustain nucleation: for decreasing heat fluxes, a decreasing number of dispersed nucleation sites producing large bubbles is observed, before the full extinction of the boiling process for a heat flux much higher than with the ultra-smooth surface. For increasing heat fluxes, the results show that ultra-smooth surfaces with a small number of imperfections deliver the best thermal performance.

Keywords Pool boiling, Nucleate Boiling, Boiling incipience, ONB, Ultra-smooth surfaces

1. INTRODUCTION

Many engineering applications requiring very high heat transfer rates are based on nucleate boiling heat transfer, which holds the potential of facilitating the transfer of a large amount of energy over a relatively narrow temperature range, with a small weight to power ratio. These characteristics are important in terms of practical industrial or domestic applications, such as heat exchangers in air conditioning systems or refrigerant plants, boilers, etc. For decades, significant advances have been made to optimize the overall thermal performance of these systems, by modifying their geometry, increasing their surface exchange area, etc. No matter what the scale of the technology, industries are continually demanding smarter and smaller

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