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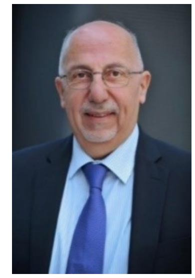

Aspects of Flow Boiling in Small to Micro Scale Heat Exchangers

Abstract: The high heat fluxes generated by modern electronic equipment necessitate a new approach to cooling these devices, as the dissipation of such high thermal loads using single-phase air or liquid heat sinks is no longer possible. The use of flow boiling in small to micro scale heat exchangers is consider as one of the most viable methods to help alleviate this thermal bottle neck – a few megawatts per meter square on average and reaching significantly higher values at the hot spots – allowing proper operation of these devices and new developments in the area. Other applications include possible use in small scale refrigeration systems, cooling of fuel cells, batteries and vehicle power electronics, solar photovoltaic panels and radar systems. The advantage of flow boiling in such systems is due to the possible small temperature difference of the substrate to be cooled reducing thermo-mechanical stresses and early failure plus small flow rates due to the high heat transfer coefficients resulting in smaller pumps and power consumption by the thermal management system. Fundamental issues that are currently being investigated in order to facilitate adoption of these small to micro scale evaporators include the definition of the macro to micro scale dimensions, the prevailing flow regimes and the effect of mass flux, heat flux, channel aspect ratio and length plus material and surface characteristics. These heat exchangers form part of a thermal system and the return temperature from the condenser and hence the possible degree of subcooling at the inlet of the evaporator is also a critical factor, bearing in mind the short lengths of the heat exchangers and the desire to achieve uniform substrate temperatures along the flow direction. The presentation will cover research in flow boiling in single tubes and channels and in multichannel heat exchangers with rectangular passages. Results for a microgap heat exchanger (single wide channel) of the same height and base area as the multi-channel heat exchangers will form benchmark comparative data. The effect of the parameters mentioned above plus the effect of coatings on the flow patterns, pressure drop and heat transfer rates will be presented. Flow instabilities will be discussed, along with ways to reduce their impact on the thermo-fluid characteristics of the evaporator. The development of correlations predicting the flow pattern boundaries, heat transfer rates and pressure drop will then be presented based on an analytical/statistical approach plus machine learning techniques. Finally, the integration of the micro evaporators in thermal management systems, which requires also the design of small-scale condensers will be discussed.

Bio: Tassos Karayiannis studied at the City University London and the University of Western Ontario. He started his career as a researcher at Southampton University and later as a British Technology Group Researcher at City University. Subsequently he worked at London South Bank University and joined Brunel University London in 2005, where he is now Professor of Thermal Engineering Leader of the Two-Phase Flow and Heat Transfer Group and Director of the Energy Efficient and Sustainable Technologies Research Centre. Professor Karayiannis has carried out fundamental and applied research in a number of single-and two-phase heat transfer areas. Initially he worked on convective heat transfer and subsequently on the enhancement of pool boiling and condensation processes using high intensity electric fields. In parallel, he carried out extensive experimental work in pool boiling heat transfer with plane and enhanced surfaces. Professor Karayiannis has also been very actively involved with research in flow boiling in small to micro tubes and micro-multi-channels. This work involves fundamental studies as well as research leading to the design of high heat flux integrated thermal management systems. He has published more than 260 chapters in books, papers and industrial reports. He chairs the Committee of the International Conference Series on Micro and Nanoscale Flows now in its 8th edition. He is a Fellow of the EI and the IMechE, Member of the Assembly for International Heat Transfer Conferences and the Chairman of the UK National Heat Transfer Committee.