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Developments in Flow Boiling in Micro Tubes and Channels

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Advances in the manufacture of electronics and high power devices, and subsequent improvements in their performance, resulted in the generation of extremely high heat fluxes and encouraged an international effort in designing small scale thermal management systems to help dissipate these thermal loads. Lack of success in this effort can result in system under performance and failure with possible catastrophic consequences. Flow boiling in mini to micro heat exchangers provides high heat transfer rates with small surface temperature variations and is a possible way to remove these high heat fluxes. Therefore, it is a current research area pursued in a number of laboratories internationally. However, some still unresolved fundamental issues which relate to the prevailing flow patterns, heat transfer rates and pressure drop in such geometries, and their dependence on key parameters as well as the design of fully integrated evaporator-condenser systems need to be fully resolved for possible full adoption of this technology.

The possible major applications of flow boiling in microchannels are first discussed in this presentation, highlighting the requirements and the challenges of the thermal management of each application. New experimental and analytical research as well as research reported in the literature on flow boiling in single tubes and rectangular multi microchannels is then presented. The presentation will include the definition of small and micro channels based on past reports and present data and then focus on factors such as the prevailing flow patterns, heat transfer mechanisms, effect of channel geometry (aspect ratio) material and surface characteristics, effect of different fluid properties, and effect of channel length. The occurrence of flow instability and reversal and their effect on heat transfer rates will also be discussed. Critical heat flux in small to micro passages and its prediction will then be presented. The effect of the above parameters under different conditions can help explain the variation in the interpretations of the fluid flow and heat transfer phenomena and the discrepancies reported in past studies.

Research and proposals of models and correlations predicting flow patterns, heat transfer rates and pressure drop is included in the presentation. Small-scale integrated thermal management systems driven by a liquid pump and vapour compression refrigeration cycles and the requirements of designing appropriate air and liquid-cooled condensers for such systems are also discussed. Finally, areas where further research is needed are identified.