Heat and Mass Transfer

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Fluid Flow, Heat Transfer and Boiling in Micro-Channels

Springer

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Preface

The subject of the book is fluid dynamics and heat transfer in micro-channels. This problem is important for understanding the complex phenomena associated with single- and two-phase flows in heated micro-channels.

The challenge posed by high heat fluxes in electronic chips makes thermal management a key factor in the development of these systems. Cooling of micro-electronic components by new cooling technologies, as well as improvement of the existing ones, is becoming a necessity as the power dissipation levels of integrated circuits increases and their sizes decrease. Miniature heat sinks with liquid flows in silicon wafers could significantly improve the performance and reliability of semi-conductor devices. The improvements are made by increasing the effective thermal conductivity, by reducing the temperature gradient across the wafer, by reducing the maximum wafer temperature, and also by reducing the number and intensity of localized hot spots.

A possible way to enhance heat transfer in systems with high power density is to change the phase in the micro-channels embedded in the device. This has motivated a number of theoretical and experimental investigations covering various aspects of heat transfer in micro-channel heat sinks with phase change.

The flow and heat transfer in heated micro-channels are accompanied by a number of thermohydrodynamic processes, such as liquid heating and vaporization, boiling, formation of two-phase mixtures with a very complicated inner structure, etc., which affect significantly the hydrodynamic and thermal characteristics of the cooling systems.

The multiplicity of phenomena characteristic of flow in heated micro-channels determined the content of the book. We consider a number of fundamental problems related to drag and heat transfer in flow of a pure liquid and a two-phase mixture in micro-channels, coolant boiling in restricted space, bubble dynamics, etc. Also considered are capillary flows with distinct interfaces developing under interaction of inertia, pressure, gravity, viscous and capillary forces.

In this book we use our own results on a number of problems related to flow and heat transfer in micro-channels, as well as those of numerous theoretical and experimental investigations published in current literature. The presented materials are easily comprehensible for engineers and applied scientists with some graduate level familiarity with fluid mechanics and theory of heat transfer.

The book consists of two parts: hydrodynamics and heat transfer of single- and two-phase media in micro-channels (Chaps. 1–7), capillary flow with distinct interfaces (Chaps. 8–11).

The book is not meant to be an undergraduate text, but can be used in graduate level courses.

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We would like to express our gratitude to our colleagues Professor J. Zakin, Dr. E. Pogrebnyak, Dr. R. Rozenblit, Dr. Z. Segal, Dr. I. Tiselj, Dr. G. Ziskind, as well as D. D. Klein (M.Sc.), Y. Mishan (M.Sc.) and R. Zimmerman (M.Sc.) for their participation in the investigations of a number of problems considered in this book.

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Contents