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## PREFACE

I was first approached by Dr. Kandlikar for the *Series in Contemporary Perspectives in Emerging Technologies* in 2011. We discussed recent advances in air cooling technology that have allowed the computer industry to hold off conversion to liquid cooling. In the early 2000s, the microprocessor roadmaps available showed an increase in heat flux, again reaching the critical mass which requires liquid cooling. This was a foregone conclusion. Right away I could think of a few specific reasons why a transition to a liquid cooling paradigm has not come to fruition.

A vast number of researchers, including myself, were lured to the challenge of providing high heat-transfer capacities to small areas. Much research emerged which centered on liquid cooling in microchannels, presenting obvious heat-transfer enhancement and a capability to meet impending industry challenges. There are examples today of extremely large-scale computing (IBM P7IH) that require liquid cooling. However, the vast majority of servers are still air cooled.

The desire to extend air cooling for as long as possible was clear. The vast majority of research for air cooling shifted to the suppliers and vendors to improve processes, efficiencies, and performance to meet industrial requirements in the near term. A great number of advances went under-represented. The research developed by suppliers turned into a competitive advantage versus their peers, and not much public disclosure occurred.

In this book I will discuss the roots of electronics cooling and how air cooling is still dominant over water cooling and will remain so for the near term. For over a century now, this area has been ripe with active research in many disciplines spanning heat transfer, thermodynamics, materials science, and structural engineering. Perhaps the most appealing feature of the electronics cooling field is the very multidisciplinary nature of the challenges being overcome. Unlike some other areas, the electronics cooling system designer must have knowledge of several disciplines to design and deliver the most optimal electronics cooling solution. In the future there will be a new roadmap laid out before us and there may be a time liquid cooling is required in mainstream computing. However, I see many current years where air cooling will play a critical role and must be improved to meet future needs.

I would like to take the opportunity to thank Dr. Kandlikar for inspiring me to put these thoughts to paper. Most importantly, I thank my wife for her support, understanding, and inspiration. Long days, late nights, and seemingly endless effort would have not been possible without her encouragement. Finally, I would like to thank my children, who continually remind me of the importance of learning new things every day. Life should be filled with the joy of discovery, and I am fortunate to experience that again through their eyes.

*Mark E. Steinke  
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