

Thermal Challenges in Next-Generation Electronic Systems

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Abstract—Thermal challenges in next-generation electronic systems, as identified through panel presentations and ensuing discussions at the workshop, Thermal Challenges in Next-Generation Electronic Systems, held in Santa Fe, NM, January 7–10, 2007, are summarized in this paper. Diverse topics are covered, including electrothermal and multiphysics codesign of electronics, new and nanostructured materials, high heat flux thermal management, site-specific thermal management, thermal design of next-generation data centers, thermal challenges for military, automotive, and harsh environment electronic systems, progress and challenges in software tools, and advances in measurement and characterization. Barriers to further progress in each area that require the attention of the research community are identified.

Index Terms—Electronics cooling, thermal management, trends.

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THE workshop “Thermal Challenges in Next-Generation Electronic Systems (THERMES 2007)” was held January 7 to 10, 2007, in Santa Fe, NM, with Suresh Garimella (Purdue University) and Amy Fleischer (Villanova University) serving as Conference Chairs. The conference was organized under the auspices of Engineering Conferences International, with partial support from grants from the National Science Foundation (NSF), Office of Naval Research (ONR), and the Defense Advanced Research Projects Agency (DARPA). Discussions stimulated by the keynote and invited lectures, panel discussions, and contributed papers as well as informal conversations, pointed to several common themes as key concerns which must be addressed for next-generation electronic systems. These include the following:

- novel low thermal resistance materials;
- power efficient design strategies;
- interface interactions;
- new measurement techniques for nanomaterials;
- electrothermal integration issues;
- tradeoffs to be made between thermal, power and acoustic considerations;
- platform level design and tradeoffs;
- needs for integrated, high-fidelity software tools;
- enhanced passive thermal management solutions;
- attention to components beyond the CPU, such as memory and cache.

All invited and contributed papers at the workshop are available in the conference proceedings [1]. The outcomes of the panel discussions are summarized in the rest of this paper.

I. PANEL 1: ELECTROTHERMAL AND MULTIPHYSICS CODESIGN OF ELECTRONICS SYSTEMS

(J. Y. Murthy, Purdue University, A. Keshavarzi, Intel Corp., E. Pop, Intel Corp., M. Stan, University of Virginia, and U. Ghoshal, NanoCoolers, Inc.)

Technology scaling continues in spite of tremendous technology development barriers, design challenges, and prohibitive costs. Miniaturization of electronic devices and circuits has led to the emergence of self-heating (Joule heating due to electron-phonon scattering) as a critical bottleneck to the performance and reliability of emerging microelectronic circuits and systems. Consequently, there is increasing emphasis on the electrothermal and multiphysics codesign of transistors, interconnects, and circuits. The panel addressed theoretical,

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