Electronic Thermal Management Materials, Components, and Systems Development:
Key Solutions for High Reliability Electronics Systems

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Semiconductor and electrical components of all types generate and must dissipate heat. Practical understanding of objectives of thermal management as a key component of system design for reliability is critical, for thermal and electrical engineers alike. This course is intended to give both a practical understanding of a range of different and critical thermal management topics and trends, but to also give up-to-date understanding of:

- New thermal materials developments; thermal materials categories, testing and characterization, and selection of thermal materials;
- Thermal management challenges current and forward-looking;
- Semiconductor trends and impact on thermal management;
- Thermal management technologies, from phase-change energy storage to vapor chambers and liquid immersion and pumped two-phase liquid cooling.

A major failure mechanism for electronic systems is inadequate heat dissipation, both from individual components and at the system level. Heat is the single largest cause of failure, with vibration and dust and other environmental factors as examples of other causes.

Categorizing and evaluating this range of thermal management technologies is increasingly important as a key component of electronic system design, vehicle electrification, energy storage (battery) design, and industry transition to higher temperature operation of power semiconductors (silicon, GaN, and SiC). This tutorial presentation will provide insight across this range of different technologies and will include examples of system implications.

Specific topics included are:

- Overview: Thermal management objectives and terminology
    - Thermal management for high temperature electronics
    - Thermal technologies technologies for semiconductor test
- Thermal challenges for very high performance processors*
- Thermal challenges for heterogeneous integration in multichip packaging*
- Semiconductor industry trends: SiC and GaN – and thermal impact*
- Thermal challenges in vehicle electrification: passenger, heavy vehicle, and aircraft propulsion systems*
- Thermal challenges in energy storage for vehicle electrification
- Thermal materials: CTE-matched rigid composites for baseplates, substrates, modules*
- Thermal interface materials*:
    - Categorization of major material types
    - Testing methodologies
    - Evaluation and selection criteria for implementation

    - Failure mechanisms for specific material types and solutions
- Graphite films and sheets: Distinguishing heat spreader materials from TIMs and why these are important materials*
- Testing methodologies for thermal materials; purposes for each methodology and interpretation of test data*
- High temperature requirements and material selection
- Phase-change latent heat storage materials for temperature control and modulation
- Categorization of thermal management hardware type*s
- Advantages and disadvantages by thermal management hardware type
- Examples of implementation for different types of electronic systems
- Liquid coolants available
- Continuing challenges and requirements for thermal management materials and systems
- Opportunities and recent new developments*

This course is intended to provide content that is appropriate for military and aerospace, vehicle electrification (including heavy ground vehicle and aircraft propulsion), and high-reliability electrical inverters and similar high-reliability systems.

Unlike many thermal management texts and courses, this content is not focused on handheld consumer devices and data centers, although much of the content is directly relevant.

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Instructor Biography

Dave Saums has forty years of experience in electronics thermal management, leading development activities for thermal materials, thermal components, and two-phase liquid cooling systems. Work experience included positions with a manufacturer of mil/aerospace grade miniature airmoving devices and a major high-volume manufacturer of liquid cold plates and heat sink assemblies. This was followed by several years of work with the first company to develop phase-change thermal interface materials, then a role as vice president of marketing for a CTE-matched composite materials manufacturer. This

work experience included hundreds of visits to OEM engineering groups globally. Saums resigned to found a business development consulting firm and has been leading that business for eighteen years. He has been the volunteer general chair of a well-known thermal technologies workshop for twenty-two years, has served as general chair and program for SEMI-THERM® Symposium, and has been general co-chair for four thermal management workshops for power electronics in the European Union. He has given approximately two hundred presentations on thermal management materials, components, and systems, and gave the first presentation globally to describe the design and implementation of a pumped two-phase dielectric liquid cooling system applied successfully to a commercialized medium voltage electrical drive, in France in January 2008. Saums also proposed and serves as the general chair for a power electronic thermal management workshop, held very successfully with Semi-Therm Educational Foundation and Binghamton University (NY) in July 2020 and again in July 2021. He was named a Fellow of the International Microelectronics, Assembly, and Packaging Society (IMAPS) in 2010.