THERMAL MANAGEMENT OF EXTREMELY HIGH POWER DENSITY ELECTRONICS (1kW/cm2)

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The high power density characteristics of wide bandgap semiconductor microwave amplifiers and other high power electronics present a tremendous challenge to the thermal designer. System reliability depends upon junction temperature operation at 150 C or below, while they may generate up to 50 W for a die size of 4 mm2, or 1 kW/cm2 in pulsed operation. Traditional thermal management techniques, such as forced air convection over heat sinks, and even direct liquid immersion and pool boiling are typically effective only for power densities in the range 1 - 100 W/cm2, or 1-10% of the desired load. As such, new ideas and new techniques are needed to even begin to approach the desired power loads.

We are actively involved in examining many possibilities for high power density thermal management, including forced convective liquid cooling, heat pipes and thermosyphons. We are currently examining a new module cooling technique that combines the strongest features of these proven methods, while drastically increasing the power dissipation rate without sacrificing simplicity and reliability. Our proposed solution is a combined thermosyphon/forced liquid convection method with the unique introduction of a solid/liquid phase change process. This will be accomplished by seeding the primary fluid with encapsulated phase change material (PCM) beads. In this system we can take advantage of traditional forced convection and high latent heat of the liquid-vapor phase change, as well as solid-liquid phase change within the microencapsulated PCM.