

TABLE 2. Thermal improvements needed by product sector.

Common Needs	<ul style="list-style-type: none">• Improved thermal interfaces• Improved thermal spreaders• High performance air cooling solutions• Advanced modeling tools
Portable	<ul style="list-style-type: none">• No significant improvements needed as long as battery power remains constrained
Office Systems <ul style="list-style-type: none">• Desktop• Server• Notebook	<ul style="list-style-type: none">• Thermal integration with EMC shielding• Low cost, compact and reliable water cooling• Low cost, compact, reliable and efficient refrigeration• High heat flux, efficient thermoelectric cooler
Netcom	<ul style="list-style-type: none">• Mechanically robust packages that minimize the thermal resistance path to air• Thermal integration with EMC shielding• Low cost, compact and reliable water cooling• Low cost, compact, reliable and efficient refrigeration• Low cost, compact, and reliable dielectric liquid cooling• High heat flux, efficient thermoelectric cooler• Abatement of heat load impact on installation
Automotive	<ul style="list-style-type: none">• Low cost, reliable heat pipe technology for automotive environment• Passive electrical components/system level packaging materials capable of operating at 150°C• Low cost liquid or refrigerant cooling systems utilizing automotive cooling components• Low cost, self-contained, phase change materials to handle transient thermal events• Analog and digital ICs capable of operating w/ $T_J = 175^\circ\text{C}$• Power transistor capable of operating w/ $T_J = 200^\circ\text{C}$
Military Defense	<ul style="list-style-type: none">• Analog and digital ICs capable of operating w/ $T_J = 170^\circ\text{C}$• Power transistor capable of operating w/ $T_J = 200^\circ\text{C}$• Capillary-pumped loops with very flat, multiple-parallel-path• Evaporators• PCBs with high-efficiency, copper, power and signal plane layers• Light-weight, high latent heat of fusion, PCMs with capability to vary the melting point• Direct immersion cooling of RF MMIC chips using sub-cooled flow boiling• Improved fan performance making the air-cooling of military electronics more feasible
Medical	<ul style="list-style-type: none">• Low cost, compact and reliable water cooling• High heat flux, efficient thermoelectric cooler• Low cost, compact, and reliable dielectric liquid cooling
LEDs	<ul style="list-style-type: none">• Development of LED packaging with low thermal resistance• Low cost, compact, and reliable dielectric liquid cooling