The inefficient dissipation of heat is a crucial problem that limits the reliability and performance of all electronic systems. Since devices have become progressively smaller, more powerful, and more complex, they dissipate much larger amounts of heat. Hence, effective thermal management, in other words, the thermal interface materials (TIMs) placed in these devices has gained utmost importance in terms of lifetime and reliability. Currently, thermal greases, epoxy-based composites, phase change materials and solders are the most common TIMs. Herein, we describe next-generation TIMs with thermal resistivity lower than existing solder TIMs and with stiffness comparable with existing epoxy-based TIMs. The approach has involved the incorporation of soft-ligand functionalized boron nitride nanosheets (BNNS) in a metal matrix to fabricate nanocomposite TIMs. The filler, BNNS, was prepared by the mechanically assisted cleavage of h-BN flakes, and functionalized with various organic ligands. Existence of functionalization was confirmed using XPS and Raman spectroscopies. Then, the functionalized-BNNS were dispersed in a copper matrix via electrocodeposition. The thermal conductivities of the nanocomposite TIMs were found to be above 200 W/(m.K) using laser flash analysis and differential scanning calorimetry. Moreover, mechanical properties were determined via nanoindentation and tensile testing, and the elastic moduli were ranged from 14 GPa to 25 GPa at various filler concentrations. As desired, these values are much smaller than that of the electroplated pure copper thin films (99-125 GPa).

We have shown that electrocodeposited nanocomposite TIMs with thermal conductivities greater than 200 W/(m.K) and elastic moduli less than 20 GPa can be produced. For these materials, the total resistance across interface was estimated to be 1.8-3.8x10^3 cm^2.K/W. Our results are significant in advancing the current state of art for TIMs when two extreme cases of epoxy-based and pure copper shim TIMs are considered.

SELECTED PUBLICATIONS


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