Improved Heat Dissipation for High-Power Systems via Nanocopper-Based Metal SMT

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Abstract

AuSn solder is often used for SMT of high power devices, LED dies and laser diodes due to its high temperature capabilities and decent thermal performance. However, the material is reaching its performance limits for ever increasing heat dissipation requirements for new LED and laser diode products that have reached the kW range. Therefore, there is a need for a new SMT that can offer higher thermal performance. To fill that need, we developed a nanocopper-based interconnect material as a robust, high-performance alternative. This solder-free nanocopper material overcomes a fundamental limitation of traditional solders in which the processing temperature imposes an upper ceiling for maximum allowable thermal operating conditions. For the first time, we can provide an interconnect material that is capable of operating at temperatures above the original processing temperature. Once fused, the material transforms back to bulk copper with a melting point of 1084 C forming contacts that can exceed 5-times the thermal and electrical conductivity of typical solder systems. The material rheology is tunable for drop-in replacement of solder on standard PCB assembly lines and other common paste dispensing production equipment. Interconnects produced from such a material can exhibit improved creep resistance and enhanced reliability in low- and high-temperature operating environments. The nanocopper material is manufactured in solution from the reduction of a copper salt with a reducing agent in the presence of amine surfactants that control particle size and protect the nanoparticles from oxidation. The manufacturing process is readily scalable with a 1 kg pilot plant currently in operation. A path to a continuous low-cost manufacturing process has been identified. A readily dispensable nanocopper paste was used to bond commercial LEDs to a thermal heat sink. A large number of test samples was fabricated to measure mechanical strength. Shear strengths as high as 80 MPa were measured using 4-6 min reflow profiles with peak temperatures around 260 C.

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