Low Thermal Resistance Insulating Thin Film Primer Using Oriented Mesogenic Epoxy Resin

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Generally, for power devices with high heat generation, flexible TIMs (Thermal Interface Materials) such as silicone grease are used to prevent thermal insulation by the air layer on the contacting surface between the heat spreader and the heat sink. However, since the heat conductive media in insulating materials is a phonon which is an elastic wave, it is known that heat from the metal is reflected and scattered at the interface with the viscoelastic material such as silicone or polymer TIM, resulting in a low heat transfer coefficient. Therefore, we have been studying the formation of polymeric primers oriented perpendicular to the substrate surface to improve phonon conduction at the interface between different materials, resulting in lower thermal resistance. We have found that self-aligning mesogenic epoxy (ME) resins can be homeotropically oriented on glass, Al, or Cu substrates to form insulating thin films with low thermal resistance. ME resin primers on glass, Al, and Cu substrates have had strong longitudinal periodic structures (monodomain structures) and relatively weak ones with no direction (polydomain structures). Since heat within the polymer is transferred in the direction of the molecular chain effectively, the high thermal conductivity of the primer in the thickness direction would be supported by the results of X-ray diffraction (XRD) analysis. The thermal conductivity in the thickness direction of 1.6 μm thickness of ME primer which was prepared on a copper foil showed 3.7 $W \cdot m^{-1} \cdot K^{-1}$, more than 10 times higher than that of conventinal epoxy resin, both by indirect measurement using thermal resistance method and direct measurement of thermal effusivity using a thermal microscope. And also by experiment using silicone grease widely used as TIM. The use of Al plates coated with primer also reduced the interfacial thermal resistance by more than 20%.