

Abstract

This dissertation examines the influence of the surface mount technology (SMT) process on the thermal characteristics of power transistors, specifically MOSFETs and IGBTs. The primary objective of the study was to determine the relationships between the properties of soldering materials, assembly process conditions, substrate type, and the thermal performance of soldered semiconductor devices. Special attention was devoted to thermal resistance and heat dissipation efficiency.

The dissertation presents issues related to transistors used in modern electronic systems, with particular emphasis on the influence of semiconductor junction temperature on device durability and reliability. Surface mount technology, as well as the structure and properties of solder joints, are also discussed. Based on a comprehensive review of the current state of knowledge, the potential for modifying solder alloys through the incorporation of nanoparticle additives is presented.

As part of the experimental work, composite solder alloys containing SiC, TiO₂, and Al₂O₃ nanoparticles were developed. Their mechanical properties, wettability, and melting temperatures were characterized. Subsequently, solder joints for MOSFET transistors were fabricated using the developed composite solder alloys, and their thermal parameters, solder void content, and microstructural features were analyzed. Advanced characterization techniques, including scanning electron microscopy (SEM) and secondary ion mass spectrometry (SIMS), were employed. These investigations made it possible to identify relationships between the properties and microstructure of solder joints, the occurrence of solder voids, and the thermal performance of the transistors.

The next stage of the research focused on analyzing the influence of soldering methods and temperature profiles on the thermal parameters of transistors. The effects of solder-joint thermal resistance and substrate type, including FR4 and MCPCB, on the heat dissipation efficiency of MOSFET devices were also examined. Experimental studies were supplemented with finite element method (FEM) simulations, and the numerical results were compared with the experimental data.

The results allow the identification of key relationships between the properties of composite solder alloys, the microstructure and void area of solder joints, SMT process conditions, and the thermal parameters of power transistors. The findings provide a basis for the optimization of both soldering materials and surface mount assembly processes used in power electronics applications.