Solder Defect Assessment Method for Power Electronic Devices Based on Mechanical Stress Wave Signals

Shuzhi Wen[1], Xiangbo Kong[1], Jinghua Zhang[1], Lisha Peng[2], Xufei Liu[1], Yangbo Liu[1], Songling Huang[1]

[1]Department of Electrical Engineering, Tsinghua University, China, [1]Department of Electrical Engineering, Tsinghua University , China

The health of a power electronic device is closely related to the mechanical stress waves released at the moment when the device is turned on and off. Research has shown the potential of mechanical stress waves in power electronic device health monitoring. However, the correlation between power device defect severity and mechanical stress wave signal characteristics has not been fully established and an effective evaluation method is currently lacking. This article uses finite element simulation methods to explore the impact of void defects in the chip solder and base plate solder of insulated gate bipolar transistor (IGBT) devices on mechanical stress wave signals. By analyzing the mechanical stress wave curves of cavity defects of multiple sizes, a method for assessing the health status of power devices based on principal component analysis (PCA) is proposed. By calculating the projection of the mechanical stress wave signal on the principal component, the characteristic quantity representing the severity of the defect is obtained. Simulation results indicate that for chip soldering defects, as the severity of defects increases, the feature values gradually decrease. Therefore, this method exhibits good evaluation performance for defects throughout the entire lifecycle. In the case of plate solder defects, this approach can effectively identify mid-to-late-stage defects in devices and can also be utilized for reliability prediction before device failure.