Special Feature: Power Semiconductor Devices

Overview

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The electrification of automobiles such as hybrid vehicles (HVs) including plug-in hybrid vehicles and fuel cell vehicles is an effective strategy to reduce global fossil fuel consumption. In this context, power semiconductor devices are critical components because they are used to control the transfer of electric energy from the battery to the electric motor. Silicon Insulated Gate Bipolar Transistors (Si IGBTs) and Si p-type intrinsic n-type (PiN) diodes have been employed in the switching device and rectifier of the power control unit of current HVs. Although progress in Si power devices remains important, overcoming their physical limits requires that research on power devices based on other semiconductor materials be conducted.

This special feature includes six papers that focus on power semiconductor devices based on three kinds of semiconductor materials, Si, silicon carbide (SiC), and gallium nitride (GaN), with two papers dedicated to each material. Regarding Si power devices, Si IGBTs and Si PiN diodes are analyzed with the aim of minimizing the switching power loss. A novel device structure based on SiC power devices is also proposed to lower the switching loss, and a quantitative analysis of dislocation defects in SiC crystals is also proposed and carried out. Finally, two new methods for analyzing GaN power devices are demonstrated. The first is an observation based on optical second-harmonic generation that visualizes the electric field distribution on the surface of GaN high electron mobility transistors. The second is based on hard X-ray photoelectron spectroscopy using a synchrotron X-ray source, and is used to analyze the defect energy states of p-type GaN caused by etching.