Overview

Author: Gourab Majumdar*

Status Quo and Prospects of Power Semiconductor Technologies

With the increasing global population as well as economic development in emerging countries, the demand for energy continues to grow. The shale gas revolution in the United States may substantially help solve energy issues, but not global warming. Renewable energies such as wind and solar power are attracting attention, and the efficient use of energy is becoming ever-more important. Over 40% of secondary energy is widely used as electric power. Therefore, the development of power electronics (PE) technologies for converting power has become essential for effectively using electricity.

By supplying not only various PE devices and machinery which help save energy but also power semiconductors as the core of such PE devices and machinery, Mitsubishi Electric is promoting research and development with a view to the sustainable development of such devices and machinery. In particular, we are improving the performance and functions of insulated gate bipolar transistor (IGBT) modules and intelligent power modules (IPMs) that incorporate peripheral circuits having optimal protection and driving functions.

These power modules combine technological elements of not only the semiconductor chip structure and process design but also package technology to ensure high-temperature and high-reliability performance. Starting from a planar gate cell structure through a trench cell structure and CSTBTs (IGBTs forming carrier accumulation layers), Si-IGBT chip technology has now reached the seventh-generation CSTBTs in which high performance is achieved by using ultra-thin wafer technology.

In recent years, to create high-temperature, high-withstand voltage semiconductors having high-speed switching performance by replacing Si wafers with SiC (Silicon Carbide) wafers for semiconductor materials, Mitsubishi Electric has developed and commercialized power metal-oxide semiconductor field-effect transistors (MOSFETs), power modules and IPMs using power Schottky barrier diode (SBD) chips.

These new semiconductors have enabled dramatic reductions in power conversion losses as well as the size and weight of power modules and their application systems, leading to the further evolution of power electronics equipment.

This issue looks at our power semiconductors, and development examples of our IGBT modules, IPMs, SiC and device technologies in the fields of consumer applications, industry, automobiles and electric railways.