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TOPICAL REVIEW

Silicon carbide and its use as a radiation detector material

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Abstract
We present a comprehensive review of the properties of the epitaxial 4H silicon carbide polytype (4H–SiC). Particular emphasis is placed on those aspects of this material related to room, high-temperature and harsh environment ionizing radiation detector operation. A review of the characterization methods and electrical contacting issues and how these are related to detector performance is presented. The most recent data on charge transport parameters across the Schottky barrier and how these are related to radiation spectrometer performance are presented. Experimental results on pixel detectors having equivalent noise energies of 144 eV FWHM (7.8 electrons rms) and 196 eV FWHM at +27 °C and +100 °C, respectively, are reported. Results of studying the radiation resistance of 4H–SiC are analysed. The data on the ionization energies, capture cross section, deep-level centre concentrations and their plausible structures formed in SiC as a result of irradiation with various particles are reviewed. The emphasis is placed on the study of the 1 MeV neutron irradiation, since these thermal particles seem to play the main role in the detector degradation. An accurate electrical characterization of the induced deep-level centres by means of PICTS technique has allowed one to identify which play the main role in the detector degradation.

Keywords: silicon carbide, radiation detector, spectroscopy, radiation hardness

(Some figures in this article are in colour only in the electronic version)

1. Fundamental material properties

1.1. Introduction

The ability to perform high-resolution energy spectroscopy and imaging of low- and high-energy radiation such as x- and gamma rays, UV photons and other uncharged and charged particles has dramatically improved in recent years. This is of great importance in a wide range of applications including medical imaging, industrial systems operating at high temperature and pressure, national security and treaty verification, environmental safety, space applications and basic science. Central to the movement of the prototype's development out of laboratory and into most electronic systems has been the remarkable progress in the crystalline quality of semiconductor materials and in device fabrication technologies.

Silicon carbide- (SiC) based semiconductor ionizing radiation detectors and electronic circuits are presently

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