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Fine ceramics (advanced ceramics, advanced technical ceramics) — Ultraviolet photoluminescence image test method for analysing polytypes of boron- and nitrogen-doped SiC crystals

Céramiques techniques — Méthode d'imagerie de photoluminescence ultraviolette pour l'analyse des polytypes dans les cristaux de SiC dopés à l'azote et au bore

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Silicon carbide (SiC), which has a close-packed crystal structure, is a promising wide-bandgap (WBG) material applicable to laser diodes (LDs), light-emitting diodes (LEDs) and electronic power devices.

Polytype inclusion generated during SiC growth is a common problem. During crystal growth, many types of SiC-stacking can occur within the bulk of a single sample. These different stacking-order types are called “polytypes.” Polytypes have identical close-packed planes but differ in the stacking sequence on the axis that is perpendicular to these planes.

SiC has more than 200 known polytypes, but most polytypes are rare, except types 2H, 4H, 6H, 15R and 3C. For example, 4H-SiC is the material used for power production in devices because of its excellent physical properties. These SiC polytypes have the same density and Gibbs-free energy but different electronic band structures. The different band structures cause different wavelengths of luminescence induced by incident ultraviolet (UV) light.

SiC can be grown using several crystal-growth techniques, such as physical vapor transport (PVT), chemical vapor deposition (CVD) and top-seeded solution growth (TSSG). Polytype inclusion in bulk SiC is one of the drawbacks during production.

Therefore, a rapid test method to discriminate between polytypes would be useful for the development and mass production of SiC crystals.

This document specifies a test method to evaluate the polytypes and their SiC ratios by UV-induced photoluminescence using non-contact and full-field measurement techniques.

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1 Scope

This document specifies a test method for determining the polytypes and their ratios in silicon carbide (SiC) wafers or bulk crystals using ultraviolet photoluminescence (UVPL) imaging. The range of SiC is limited to semiconductor SiC doped with nitrogen and boron to have a deep acceptor level and a shallow donor level, respectively. The SiC wafers or bulk crystals discussed in this document typically show electrical resistivities ranging from 10^{-3} ohm · cm to 10^{-2} ohm · cm, applicable to power electronic devices.

This method is applicable to the SiC-crystal 4H, 6H and 15R polytypes that contain boron and nitrogen as acceptor and donor, respectively, at concentrations that produce donor-acceptor pairs (DAPs) to generate UVPL. In 4H-SiC the boron and nitrogen concentrations typically range from 10^{16} cm^{-3} to 10^{18} cm^{-3}. Semi-insulating SiC is not of concern because it usually contains minimal boron and nitrogen; therefore deep level cannot be achieved.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
ultraviolet photoluminescence
UVPL
wavelength shifting to a longer wavelength by the interaction of photons with matter

3.2
donor-acceptor pair
DAP
state of a solid in which an electron-hole is created when a photon or other energy is absorbed

3.3
DAP recombination energy
photon energy emitted by the recombination of the *donor-acceptor pair* (3.2)