IEC 61435

Edition 2.0 2013-08

INTERNATIONAL STANDARD

Nuclear instrumentation – High-purity germanium crystals for radiation detectors – Measurement methods of basic characteristics

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE V

ICS 27.120

ISBN 978-2-8322-1033-8

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

NUCLEAR INSTRUMENTATION – HIGH-PURITY GERMANIUM CRYSTALS FOR RADIATION DETECTORS – MEASUREMENT METHODS OF BASIC CHARACTERISTICS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61435 has been prepared by IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 1996 and constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

– Review the existing requirements.
– Update the terminology and definitions.

The text of this standard is based on the following documents:

FDIS	Report on voting
45/754/FDIS	45/760/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Detector manufacturers demand numerical data that can be used to predict the performance of a detector having approximately coaxial geometry. However, because of the many variations in the physical characteristics, the completed detector performance cannot be fully predicted from measurements of the crystal manufacturer. This standard defines terminology and test methods for determining basic crystal parameters such as net electrically active impurity concentrations, deep-level impurity-centre concentration and crystallographic quality of crystals.

Production of germanium crystals of the necessary size and defined purity for high-purity germanium (HPGe) detectors for detection of ionizing radiation has special problems in characterization resulting from the high resistivity of the material (~10 kΩ·cm at 77 K), from the degree of impurity compensation, and from difficulties in suitably describing the impurity distribution in the large volume that may form a single device. Existing standards do not cover these problems.

One of the most important characteristics of HPGe is the net electrically active impurity concentration $(N_A - N_D)$ because it determines the depletion voltage required for an operating detector. The usual practice has been to determine $(N_A - N_D)$, with the sign indicating n-type or p-type, on the basis of transport measurements using the Van der Pauw method [1][1] on lamellar samples immersed in liquid nitrogen (LN).

In this technique, $(N_A - N_D)$ can be computed either from the resistivity or from the Hall coefficient. These in turn are obtained from a series of electrical measurements made on the sample.

1 Numbers in square brackets refer to the Bibliography.

NUCLEAR INSTRUMENTATION – HIGH-PURITY GERMANIUM CRYSTALS FOR RADIATION DETECTORS – MEASUREMENT METHODS OF BASIC CHARACTERISTICS

1 Scope and object

This International Standard is applicable to high-purity germanium crystals used for radiation detectors for gamma-rays and X-rays. Such germanium is monocrystalline and has a net concentration of fewer than 10^{11} electrically active impurity centers per cm^3, usually of the order of 10^{10} cm^{-3}.

This International Standard specifies terminology and test methods for measurements of basic characteristics of high-purity germanium crystals. These characteristics are net electrically active impurity concentrations (hereinafter $(N_A - N_D)$), deep-level impurity-centre concentration and crystallographic quality of crystals.

These test methods are not mandatory but have found general use in the industry and provide verifiable and desired information to the detector manufacturer.

Test methods for completed assembled germanium detectors are given in IEC 60973 and IEC 60759.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 600050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment, and detectors*

IEC 60050-521:2002, *International Electrotechnical Vocabulary (IEV) – Part 521: Semiconductor devices and integrated circuits*