



BSI Standards Publication

Nanotechnologies — Positron annihilation lifetime measurement for nanopore evaluation in materials

National foreword

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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
3.1 General	1
3.2 Experimental set-up	2
4 Symbols and abbreviated terms	2
5 Principle	3
6 Overview of the positron annihilation lifetime measurement	4
7 Apparatus	7
7.1 Specification of the detector	7
7.2 Discrimination of the detected signals	8
7.3 Measurement conditions	8
8 Preparation of the positron source	9
9 Preparation of the measurement specimen	9
10 Data analysis	9
11 Reporting	10
11.1 Specific values	10
11.2 Pore dimension	11
12 Reference materials	11
Annex A (informative) Interlaboratory comparison	12
Annex B (informative) Configuration of the apparatus	15
Annex C (informative) List of parameters and measurement conditions	19
Bibliography	21

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

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

This document describes a method for measuring and reporting the lifetime of *ortho*-positronium utilizing the positron annihilation lifetime technique. Some of the positrons introduced into insulating materials, like oxides and organic polymers, can form the spin parallel positron-electron bound state *ortho*-positronium, which tends to localize in voids. In its trapped state, *ortho*-positronium annihilates with a lifetime that is less than its intrinsic lifetime of 142 ns in vacuum via a two-gamma annihilation process, where this lifetime component is well correlated with the void dimension. Based on this principle, one can evaluate the average porosity originating from nanometer size voids, such as free volumes in polymers. It is well documented that the positron annihilation lifetime technique is a powerful tool for characterizing the nanopores of various functional materials. Increased demands on the reliable evaluation of nanopores using this technique have emerged for various industrial applications.

This document describes a method for performing positron annihilation lifetime measurements to analyse the lifetime of the *ortho*-positronium ranging from 1 ns to 10 ns (ascribed to a pore size from approximately 0,3 nm to 1,3 nm in diameter), observed for polymeric materials. It also contains measurement procedures, data analysis, and reporting sections. In the annexes, the results of an interlaboratory comparison using two types of reference materials conducted by eight participating institutions, are described, followed by details of measurement systems that are based on the available analogue and digital methods, and a list of parameters and measurement conditions provided as a guide to the user.

Nanotechnologies — Positron annihilation lifetime measurement for nanopore evaluation in materials

1 Scope

This document describes a method for performing positron annihilation lifetime measurements using a ^{22}Na positron source that decays with β^+ emission. The β^+ (positron) lifetime is determined from a measurement of the lifetime of the *ortho*-positronium which ranges from 1 ns to 10 ns (ascribed to a pore size from approximately 0,3 nm to 1,3 nm in diameter), as observed for polymeric materials in which the positronium atoms mostly annihilate via a two-gamma annihilation process.

This document is not applicable to thin surface layers (that are less than several micrometers).

This document does not apply to measuring:

- non-positronium forming materials;
- positronium-forming materials that induce a spin conversion reaction;
- positronium-forming materials that contain chemicals influencing the annihilation process of *ortho*-positronium by chemical reactions;
- positronium-forming materials that contain mesoporous silica gels with a large contribution from the three-gamma annihilation process.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org>

3.1 General

3.1.1

positronium

bound state of a positron and an electron

3.1.2

positron lifetime

component lifetime corresponding to the annihilation of a large number of positrons or positroniums, and extracted from a measured lifetime spectrum