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IEEE Standard for Relaxor-Based Single Crystals for Transducer and Actuator Applications

IEEE Ultrasonics, Ferroelectronics and Frequency Control Society

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IEEE Standard for Relaxor-Based Single Crystals for Transducer and Actuator Applications

Sponsor

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of the
IEEE Ultrasonics, Ferroelectronics and Frequency Control Society

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IEEE-SA Standards Board

Abstract: The physical and electromechanical requirements for relaxor-based piezoelectric single crystals of lead magnesium niobate–lead titanate (PMN-PT) and lead zinc niobate–lead titanate (PZN-PT) solid solutions of perovskite structure, with poling along the crystallographic *c*-axis (i.e., the [001]-direction), that are intended for fabrication into single plates, multilayer plate devices, and composites with other passive materials for use in medical, industrial, and military transducers, actuators, and sensors are covered in this standard. Definitions of terms and recommended practices for measuring the physical and electromechanical properties of these materials are also included in this standard.

Keywords: actuators and sensors, crystal compositions, crystal properties and measurements, crystal property specifications, electromechanical transducers, IEEE 1859™, lead magnesium niobate–lead titanate solid solution, lead zinc niobate–lead titanate solid solution, piezoelectric single crystals, PMN-PT, PZN-PT

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Jun Luo, *Technical Editor*
Jian Tian, *Technical Editor*

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Stuart Blacker
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Christopher Lynch
James Powers
Harold Robinson
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Glenn Whitworth
Carl Wu
Shujun Zhang

Early versions of this standard benefited from the leadership of Seung-Eek (Eagle) Park and Sorah Rhee and the initiative and valued input of Yohachi (John) Yamashita.

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

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Introduction

This introduction is not part of IEEE Std 1859-2017, IEEE Standard for Relaxor-Based Single Crystals for Transducer and Actuator Applications.

In 2000, Yohachi (John) Yamashita recommended the development of a material standard for the relaxor-based piezoelectric single crystals (piezocrystals) of lead magnesium niobate–lead titanate solid solution (PMN-PT) and lead zinc niobate–lead titanate solid solution (PZN-PT) to support their maturation and use in medical and naval applications. As a result, a group of crystal growers, device designers, and materials researchers met; they concurred that a material standard should be developed for a set of piezocrystal compositions that have technological value. The standard was to identify a common set of material properties required by device designers and provide reliable values for these properties for each composition. Other information relevant to the use of piezocrystals that could facilitate discussions between device designers and crystal growers was to be included. Since then, biannual meetings have served to develop the scope and contents of the standard.

In 2012, with the sponsorship of the IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society (UFFC), the P1859 Relaxor-Based Single Crystals Working Group was established. The working group has developed a material standard that covers the physical and electromechanical properties required for relaxor-based piezoelectric single crystals of [001]-poled PMN-PT and PZN-PT compositions.

This standard is structured into the following clauses and annexes:

— Clause 1: Scope

— Clause 2: Normative references

— Clause 3: Definitions, acronyms, and abbreviations

— Clause 4: Characteristics and preparation of single-crystal specimens

— Clause 5: Classification and requirements

— Annex A (informative) Purchase information requirements

— Annex B (informative) Packaging

— Annex C (normative) Crystal uniformity within the plate or wafer

— Annex D (informative) Bibliography

Acknowledgments

The following standards are referenced with permission from ASTM International:

— ASTM B905-00(2010), Standard for Assessing the Adhesion of Metallic and Inorganic Coatings by the Mechanized Tape Test[1]

— ASTM D150-98, Standard for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation [B1][2]

— ASTM D2149-97, Standard for Permittivity (Dielectric Constant) and Dissipation Factor of Solid Dielectrics at Frequencies to 10 MHz and Temperatures to 500 °C [B2]

— ASTM D3359-97, Standard for Measuring Adhesion by Tape Test

[1]Information on references can be found in Clause 2.
[2]The numbers in brackets correspond to those of the bibliography in Annex D.

Contents

IEEE Standard for Relaxor-Based Single Crystals for Transducer and Actuator Applications

1. Scope

This standard covers the physical and electromechanical requirements for relaxor-based piezoelectric single-crystal materials with inherent multiple domains intended for fabrication into single plates, multilayer plate devices, and composites with other passive materials for use in medical, industrial, and military transducers, actuators, and sensors.

This standard specifically covers [001]-poled lead magnesium niobate–lead titanate (PMN-PT, or PMNT) and lead zinc niobate–lead titanate (PZN-PT, or PZNT) single-crystal compositions.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI/IEEE Std 176-1987, IEEE Standard on Piezoelectricity.[3,4,5]

ASTM B905-00(2010), Standard Test Methods for Assessing the Adhesion of Metallic and Inorganic Coatings by the Mechanized Tape Test.[6]

ASTM D3359-09e2, Standard Test Methods for Measuring Adhesion by Tape Test.

3. Definitions, acronyms, and abbreviations

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