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Fine ceramics (advanced ceramics, advanced technical ceramics) — Methods of test for ceramic coatings — Determination of internal stress in ceramic coatings by application of the Stoney formula

Céramiques fines (céramiques avancées, céramiques techniques avancées) — Méthodes d'essai des revêtements céramiques — Détermination de la contrainte interne des revêtements céramiques par application de la formule de Stoney

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 documents 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 206, *Fine ceramics*.

This second edition cancels and replaces the first edition (ISO 19674:2017), which has been technically revised.

The main changes are as follows:

— in the Scope, the substrate is limited to isotropic ones;

— in Clause 5, the contents of EXAMPLE are all deleted due to an incorrect Formula (2) and its weak correlation;

— in 7.5, the calculation for R_{exp} has been revised;

— at the end of 7.5, a schematic diagram (Figure 1) and an approximate calculation of R_{exp} from deflection has been added and the formula renumbered to Formula (3);

— Annex B has been added.

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Introduction

There is an increasing use of coatings to improve the functional performance of materials and components. This can be to protect against damage due to exposure to demanding environments including high stresses and aggressive chemical environments, but can also be to modify many other properties, e.g. thermal conductivity through thermal barrier coatings, friction through low friction coatings, such as diamond like carbon (DLC), and optical reflectivity through coatings with controlled optical properties.

Appropriate choice of coatings for particular applications depends on the mechanical and other functional requirements that arise. One factor that can be crucial in determining coating performance and lifetime is the residual stress that is generated by the deposition process and/or by thermal expansion mismatch between the coating and the substrate as the component is cooled from the processing temperature.

This document describes the application of a simple experimental technique using the Stoney formula to analyse the coating induced bending of coupons, of known mechanical properties, to determine the residual stress in the coating.

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Methods of test for ceramic coatings — Determination of internal stress in ceramic coatings by application of the Stoney formula

1 Scope

This document specifies a method for determination of the internal stress in thin ceramic coatings. The internal stress is determined by application of the Stoney formula to the results obtained from measurement of the radius of curvature of isotropic strips or discs with single-face coating.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Principle

Coating stress often plays a major role in the performance of coated tools and machine parts. Different techniques have been developed for the determination of coating stress. The technique considered in this document calculates the stress from measurement of the bowing of thin discs or strips of well-characterized materials of known thickness that have been coated on one side only. It is assumed that the deformation is elastic, i.e. if the coating were to be removed the substrate would return to its initial shape.

Provided that the coating is thin compared to the thickness of the substrate (coating thickness <2 % of substrate thickness), that the curvature has a spherical form and that the substrate was initially flat or of known curvature, then the stress in the coating can be calculated using the Stoney formula (see 7.6) without the need to know the elastic properties of the coating material.

The technique does require accurate knowledge of the thickness of the coating, the thickness of the substrate, and Young's modulus and Poisson's ratio of the substrate material.

NOTE 1 Coating thickness can be determined by techniques such as step height measurement (see ISO 18452), crater grinding (see ISO 26423), and cross-sectioning (see EN 1071-10[4]).

As ceramic coatings are normally deposited at elevated temperatures, the stress determined at any other temperature will be a combination of the intrinsic growth stress and stress introduced by virtue of the difference in thermal expansion between the coating and the substrate.

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