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Nanotechnologies - Nano- and micro- scale scratch testing

Nanotechnologies - Essais de rayure aux échelles nano- et micro métriques

Nanotechnologien - Nano- und Mikro-Ritzprüfung

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (CEN/TS 17629:2021) has been prepared by Technical Committee CEN/TC 352 “Nanotechnologies”, the secretariat of which is held by AFNOR.

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Introduction

The test procedure is intended to complement other standards which are concerned with the scratch resistance of materials. This procedure extends the use of the nano- and micro- single pass scratch test to bulk and coated materials, additionally covering the use of multiple pass nano- and micro- scratch tests.

The method described is not intended to be used to define how particles are released from a surface under this type of damage.

Several measurement techniques are described, according to the following procedures:

— Constant force scratch test

  Single movement of a normally loaded probe (constant force) onto a test piece; friction force and displacement of the probe (relative to the test piece) are measured along the scratch path.

— Ramped force scratch test

  Single movement of a progressively normally loaded probe (ramped force) onto a test piece; friction force and displacement of the probe (relative to the test piece) are measured along the scratch path.

— Multi-pass unidirectional constant force scratch test

  Repeated movement of a normally loaded probe (constant force) onto a test piece, following the same track; the variation in friction force and displacement of the probe (relative to the piece test) are measured along the scratch path. First introduced by Bull and Rickerby [1], this test is also called “nanowear” when used in the nano scratch range and provides information regarding the fatigue behaviour of the test piece as an effective low cycle fatigue test.

— Progressive force “3-scan” scratch test

  Three repetitive unidirectional movement of a normally loaded probe onto a test piece, along the same track. The first movement of the probe is carried out at constant force (low force) and performed as a topography scan of a non-scratched test piece surface. The second movement of the probe is achieved with a progressively increased normal force onto the test piece (from low to high forces). The third movement of the probe is similar to the first movement, at low force, to acquire a topography of the scratch carried out in the test piece. This test is also called “scratch topography multi-pass test” and was first reported by Wu and co-workers [2], [3], which enables identification of failure mechanisms and provides more details regarding the impact of stress such as the critical force for onset of non-elastic deformation and the yield pressure (estimated from mean pressure at critical force).

1 Scope

This document specifies a method for measuring the scratch resistance and failure behaviour for advanced materials and coatings by means of nano- and micro- scale scratch experiments. The method provides data on both the physical damage to test-pieces and the friction generated between the probe and the test-piece under single pass and multiple pass conditions. The force range in these tests is from 1 µN up to 2 N.

The test method is not applicable to coatings as defined in EN ISO 4618 [18].

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 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 https://www.electropedia.org/

3.1
nanoscale
size range between approximately 1 nm and 100 nm

Note 1 to entry: Properties that are not extrapolations from a larger size are predominately exhibited in this size range.

Note 2 to entry: The lower limit in this definition (approximately 1 nm) is introduced to avoid single and small groups of atoms from being designated as nano-objects or elements of nanostructures, which might be implied by the absence of a lower limit.

Note 3 to entry: EN ISO 14577-1 defines nano range for indentation depth as less than 200 nm and has a force criterion for tests in the micro range.

[SOURCE: CEN ISO/TS 80004-1:2015, 2.1 [17], modified]

3.2
microscale
size range between 100 nm and 100 µm

3.3
topographical profiling
scans carried out for topographical profiling sequence (e.g. 3-pass scratch test: pre-scanning and post-scanning under minimal force), the purpose of which is to measure the topographical profile of the surface before and after the scratch test

Note 1 to entry: The load of the scan should be kept to a minimum to avoid plastic deformation.

Note 2 to entry: Scans have to move in the same direction to avoid uncertainties in displacement recording and scanning movements have to be longer than scratching ones to cover the starting- and ending part of the scratch and providing undeformed areas for checking instrument drift. The force during the scanning movements shall be low enough to ensure that any deformation is elastic.

Note 3 to entry: The probe radius needs to be small enough to give sufficient resolution for the analysis of the profile of the surface.