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Kovinske prevleke - Merjenje debeline prevleke - Profilometrijska metoda (ISO/DIS 4518:2020)

Metallic coatings - Measurement of coating thickness - Profilometric method (ISO/DIS 4518:2020)

Metallische Überzüge - Messen der Schichtdicke - Profilometrisches Verfahren (ISO/DIS 4518:2020)

Revêtements métalliques - Mesurage de l'épaisseur - Méthode profilométrique (ISO/DIS 4518:2020)

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Metallic coatings — Measurement of coating thickness — Profilometric method

Revêtements métalliques — Mesurage de l'épaisseur — Méthode profilométrique

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Foreword

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This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

This second edition cancels and replaces the first edition (ISO 4518:1980), which has been technically revised.

The main changes compared to the previous edition are as follows:

— optical profilometers like confocal microscopes or interference microscopes added as alternatives to stylus instruments for the measurement of the step height;

— description of more modern stylus profilometers added;

— editorial changes.

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.

Metallic coatings — Measurement of coating thickness — Profilometric method

1 Scope

This document specifies a method for the measurement of metal coating thickness by first forming a step between the surface of the coating and the surface of its substrate and then measuring the step height using a profile recording instrument. It covers the instrumentation characteristics and the procedure appropriate to this specific application of profilometric methods.

The method is applicable to the measurement of thicknesses of metal coatings from 0,01 µm to 1 000 µm on flat surfaces and, if appropriate precautions are taken, on cylindrical surfaces. It is highly suitable for the measurement of minute thicknesses but, for thicknesses of less than 0,01 µm, surface flatness and surface smoothness are very critical and accordingly, the method is not recommended for use down to the lowest level of measurement usual for electronic stylus instruments. The method is suitable for measuring coating thicknesses when preparing coating thickness reference standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2177, *Metallic coatings — Measurement of coating thickness — Coulometric method by anodic dissolution*

3 Terms and definitions

No terms and definitions are listed in this document.

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 http://www.electropedia.org/

4 Principle

Formation of a step either by dissolving part of the coating (acceptance testing) or by masking a portion of the substrate prior to coating (production inspection). Measurement of the height of the step using a profile recording instrument.

5 Instrumentation: Operational parameters and measurement characteristics

5.1 Types of profile recording instruments

Either of three types may be used:

a) contact stylus instruments, known as surface analysers and surface profile recorders, generally used to measure surface roughness but which, for the purposes of this document, are used to record the profile of a step;

b) inductive measuring probe or displacement sensor (incremental oder absolute) capable of recording the profile of a step.

c) optical profilometers, i. e. white-light interference microscopes or confocal microscopes (ordinary, laser scanning, or chromatic), which are generally used to measure surface topographic information and 3D surface roughness but which, for the purposes of this document, are used to record and evaluate the profile of a step.

Stylus instruments may have a greater utility, being suitable for roughness and form measurements, while measuring probes or displacement sensors may be simpler in construction. Stylus instruments designed only for roughness generally cover a ranges of coating thickness from 0,005 µm to 250 µm, the other contact instruments up to some 1 000 µm.

5.2 Stylus instruments

These instruments are used to record the profile of a surface and have the following components.

5.2.1 A pick-up with a conical or pyramidal stylus having an included angle of 1,05 rad (60°) or 1,57 rad (90°) and a nominal tip radius, in the direction of the traverse, of 2 µm, 5 µm, 10 µm or 50 µm. The force of contact on the test surface shall not exceed the appropriate value given in Table 1.

Table 1 — Maximum force on stylus

Nominal value of stylus tip radius, µm	2	5	10	50**
Maximum static force at the mean level of the stylus, mN*	0,7	4	16	10**

* 1 mN ≈ 0,1 gf

** Values useful for low-hardness metals such as tin and lead.

5.2.2 A traverse unit that moves the pick-up relative to a datum skid or, in those cases where the skid may result in damage to the surface or introduce distortion of the step to be measured, a datum surface having nominal form of the profile.

5.2.3 A component that unites the amplifier and the recording instrument in an electronic controller and a computer software, which can display and print the digitized data at any desirable vertical and horizontal magnification (zoom).

Old-fashioned instruments with purely analogous measuring value processing are equipped with an amplifier with firm amplifying steps and a recording instrument that plots the amplified values (V_v) over the amplified values of the horizontal movement of the traverse unit (V_h).

5.2.1.4 Profile recording instruments will typically furnish the following measuring characteristics:

— traverse length: 1 mm to 100 mm

— range of thickness measurement: 0,005 µm to 250 µm

— height resolution (dependent on the range of measurement): 0,000 5 µm to 1 µm.

5.3 Inductive measuring probes or displacement sensors

5.3.1 The design of inductive measuring probes or displacement sensors is much like that of the electronic stylus instruments (5.2), the principal difference being that the large-radius stylus does not plot the microprofile of the surface.

5.3.2 Typical examples of the measuring characteristics and the operational parameters of a inductive measuring probe or a displacement sensor are as follows:

A linearity of not less than 0,5 %, a table providing a rectilinear motion to the surface to be traversed, and suitable amplifiers, and using the following operational parameters:

— radius of stylus: 250 µm

— maximum magnification: × 50 000

— static stylus force: 0,12 N

will furnish the following measurement characteristics:

— traverse length: 100 mm

— range of thickness measurement: 1 µm to 1 000 µm

— height resolution (dependent on the range of measurement): 0,02 µm to 20 µm.

5.4 Optical profilometers

Optical profilometers are based on the technology of optical microscopes, use similar objectives and have thus similar lateral resolution, but due to the interference or confocal technique and digital data evaluation, they have a good height resolution.

Typical examples of the measuring characteristics of optical profilometers are as follows:

For white-light interference microscopes:

— range of thickness measurement: 10 × *Ra* to 50 % of the maximum measurable height difference (depending on the instrument)

— height resolution: 0.5 nm

For confocal microscopy:

— range of thickness measurement: 10 × *Ra* to 50 % of the maximum measurable height difference (depending on the instrument)

— height resolution: 0.5 nm

For laser-scanning confocal microscopes:

— range of thickness measurement: 10 × *Ra* to 50 % of the maximum measurable height difference (depending on the instrument)

— height resolution: 0.5 nm

For chromatic confocal microscopes:

— range of thickness measurement: 10 × *Ra* to 50 % of the maximum measurable height difference (e.g. 0,15 mm or 0,5 mm)

— the height resolution depends on the selected sensor and the measurable height difference: the larger the working range, the worse the resolution.

6 Factors relating to accuracy

6.1 Profile record

Because the thickness measurement is made from the recorded profile, errors will arise if the recording does not give a faithful reproduction of the step at a suitable magnification. Inaccurate recordings may reflect the quality or improper adjustment of the recording instrument.

6.2 Vertical magnification (only for instruments with chart recorders)

If the vertical magnification is too low, measurement precision will be poor. It should be set to take maximum advantage of the chart width.

6.3 Graphical measurements

If the test surface is not parallel to the reference (datum) surface, the recording of the horizontal surface is sloped with respect to the chart grid; the vertical portion of the step is also sloped but it may still be vertical on the chart grid, depending on the vertical and horizontal magnifications, on the radius of the stylus and finally on the height of the step (i.e. thickness). When the profile is sloped, a common error is to measure the perpendicular distance between the mean lines of the profile without correcting for the differences between the horizontal and vertical magnifications.

Modern instruments with software-based evaluation can correct for such effects.

To avoid these errors or additional mathematical calculations, the datum and test surfaces shall be parallel. This may be accomplished by the use of an appropriate jig or fitting.

6.4 Applied force (only for profilometers with stylus)

If the force on the stylus is too high, the stylus produces a scratch or deformation which may introduce a measurement error. The force should be kept to a minimum and generally should not exceed the appropriate values given in Table 1.

6.5 Stylus diameter and surface roughness

If a small-diameter stylus is used on a rough surface, the step height may be difficult to measure accurately because of poor definition of the extremes of the recorded step. A large diameter stylus minimizes this difficulty.

If the substrate and coating surfaces are of different roughnesses, the recorded step profile may be misleading to the extent that the stylus rides the high spots more on one surface than the other because of different peak to peak spacings. A small-diameter stylus tends to reduce this error.

A small-diameter stylus equipped with an electronic filter to smooth out the profile can be advantageous, but may round the corners of the step profile.

6.6 Surface roughness

In principle, the roughness of a recorded substrate (peak to valley height of the surface profile) should not exceed 10 % of the step height.

When optical profilometers are used, the lateral dimensions of the surface profile elements (e.g. *RSm*) shall exceed a few times the wavelength of the light, otherwise a plane cannot be determined.