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Metallic and other inorganic coatings — Electrodeposited gold and gold alloy coatings for electrical, electronic and engineering purposes — Specification and test methods

Revêtements métalliques et autres revêtements inorganiques — Dépôts électrolytiques d'or et d'alliages d'or pour usages électrique, électronique et industriels — Spécification et méthodes d'essai

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 27874 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

This first edition of ISO 27874 cancels and replaces ISO 4523:1985, ISO 4524-1:1985, ISO 4524-4:1985 and ISO 4524-5:1985, of which it constitutes a technical revision.

Introduction

The engineering uses of electrodeposited gold and gold alloy coatings have expanded with the growth of the electrical and electronic industries. Low voltages and currents, dry circuits and microwave frequencies require low-resistance interconnection systems, connectors and waveguides. Non-tarnishing, low-resistance gold coatings were the logical choice for connectors where the stability of contact surfaces was critical. The need to improve the wear resistance of gold coatings led to the development of new electroplating solutions containing controlled amounts of metallic and non-metallic additives that either changed the composition or altered the crystal structure of the coating. The special needs of the printed-circuit industry led to the development of acid gold electroplating solutions that contained no free cyanide, yielding coatings that are hard, bright and solderable. Formulations for high-speed electroplating up to current densities of 200 A/dm^2 were introduced for continuous strip, stripe or spot gold and gold alloy coatings.

The high cost of gold metal has led to the development of selective and thickness profile plating techniques to limit the use of the metal to the active areas only of the components, where the gold is required. Designers will therefore often specify the area requiring gold electroplating as well as the thickness profile, if required, by reference to suitably marked drawings.

With the introduction of many new gold electroplating formulations and the proliferation of engineering applications, the need for technical standards that specify the requirements of electrodeposited gold and gold alloy coatings, as well as the test methods to ensure that the specified requirements are met, is critical. Composition, appearance, hardness, thickness, purity, porosity, wear resistance, solderability, electrical contact resistance, infrared reflectivity and other properties must be controlled to produce high-quality gold and gold alloy coatings for engineering purposes.

Metallic and other inorganic coatings — Electrodeposited gold and gold alloy coatings for electrical, electronic and engineering purposes — Specification and test methods

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1 Scope

This International Standard specifies the requirements for electrodeposited gold and gold alloy coatings for electrical, electronic and other engineering applications on metallic and non-metallic substrates. It also specifies test methods for measuring the properties of the coatings.

Although this International Standard does not specify the condition, finish or surface roughness of the basis material prior to electroplating, the appearance and serviceability of electroplated gold or gold alloy coatings depends on the condition of the basis material. It is essential that the purchaser specify the surface finish and roughness of the basis material in order to conform to the product requirements.

This International Standard does not apply to coatings on threaded articles or to coatings on sheet or strip in non-fabricated form.

2 Normative references

The following referenced documents are indispensable for the application 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 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

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

ISO 2080, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

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

ISO 2819, *Metallic coatings on metallic substrates — Electrodeposited and chemically deposited coatings — Review of methods available for testing adhesion*

ISO 3497, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

ISO 3543, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method*

ISO 3868, *Metallic and other non-organic coatings — Measurement of coating thicknesses — Fizeau multiple-beam interferometry method*

ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness*

ISO 4516, *Metallic and other inorganic coatings — Vickers and Knoop microhardness tests*

ISO 4518, *Metallic coatings — Measurement of coating thickness — Profilometric method*

ISO 4519, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO 4524-2, *Metallic coatings — Test methods for electrodeposited gold and gold alloy coatings — Part 2: Mixed flowing gas (MFG) environmental tests*

ISO 4524-3:1985, *Metallic coatings — Test methods for electrodeposited gold and gold alloy coatings — Part 3: Electrographic tests for porosity*

ISO 4524-6, *Metallic coatings — Test methods for electrodeposited gold and gold alloy coatings — Part 6: Determination of the presence of residual salts*

ISO 9587, *Metallic and other inorganic coatings — Pretreatment of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

ISO 10308, *Metallic coatings — Review of porosity tests*

ISO 12687, *Metallic coatings — Porosity tests — Humid sulfur (flowers of sulfur) test*

ISO 14647, *Metallic coatings — Determination of porosity in gold coatings on metal substrates — Nitric acid vapour test*

IEC 60068-2-20, *Environmental testing — Part 2-20: Tests — Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064 and ISO 2080 and the following apply.

3.1
gold or gold alloy coating
electrodeposited gold or gold alloy having intentional alloying elements in its composition

3.2
double-layer gold or gold alloy coating
gold or gold alloy coating consisting of two discrete layers of differing gold contents

3.3
multilayer gold or gold alloy coating
gold or gold alloy coating consisting of more than two discrete layers of differing gold contents

4 Information to be supplied to the electroplater

4.1 Essential information

The following information shall be supplied by the purchaser to the electroplater in writing in the purchase order or contract, or on engineering drawings:

a) the designation (see Clause 5);

b) the significant surface of the article, indicated, for example, as dimensioned areas on drawings or by the provision of suitably marked samples;

c) the nature, condition and finish of the basis metal if they are likely to affect the serviceability and/or the appearance of the coating (see Clause 1);

d) the position on the surface of any unavoidable defects, such as rack marks (see 6.2);

e) the finish required, for example bright, dull or another type, preferably accompanied by approved samples of the finish (see 6.2);

f) the method of porosity testing to be used and the permitted number and location of acceptable pores (see 6.4);

g) the tensile strength of the part and the requirements for any heat treatment prior to, or after, electroplating (see 6.7 and 6.8);

h) sampling methods, acceptance levels and any other inspection requirements if different from those specified in ISO 4519 (see Clause 7);

i) the requirements for coating thickness, including positions of measurement as indicated on dimensioned drawings (see 6.3);

j) the requirements for adhesion testing (see 6.9).

4.2 Additional information

The following additional information may be required and, if so, shall be specified by the purchaser in writing, for example in the contract or purchase order, or on drawings:

a) the composition of the coating and details of intentional alloying elements and undesirable impurities (see 6.6);

b) any special cleaning procedures to be used;

c) any special requirements for undercoats (see 6.15 and Annex A);

d) any requirements for the composition and thickness of each layer in double or multilayer coatings (see Clause 3);

e) the electrical properties of the coating and the methods of test to be used (see 6.10);

f) the microhardness of the coating and the test method to be used (see 6.11);

g) any requirements for solderability and the test method to be used (see 6.12);

h) any requirements for wear resistance and the test method to be used (see 6.13);

i) the ductility of the coating and the method of test to be used (see 6.14);

j) any requirements for the freedom from surface contamination of the finished articles (see 6.16);

k) the agreed mean density of a gold alloy coating if the thickness measurement method requires a density correction (see Annex B);

l) any requirements for accelerated-corrosion testing (see 6.5);

m) any other requirements, such as a residual-salts test, (see 6.16).

5 Designation

5.1 General

The designation shall appear on engineering drawings, in the purchase order, in the contract or in the detailed product specification.

The designation specifies, in the following order, the basis metal, the specific alloy (optional), stress relief requirements, the type(s) and thickness(s) of undercoats (when present), the thickness and composition of the gold or gold alloy coating or coatings (when double or multilayer coatings are specified), and supplementary treatments such as heat treatment to reduce susceptibility to hydrogen embrittlement.

5.2 Designation specifications

The designation shall comprise the following:

a) the term, “electrodeposited coating”;

b) the number of this International Standard (ISO 27874);

c) a hyphen;

d) the chemical symbol of the basis metal (see 5.3);

e) a solidus (/);

f) if appropriate, the chemical symbol for an undercoat metal followed, if necessary, by a number giving the thickness of the undercoat in micrometres (see 6.15 and Annex A);

g) a solidus (/);

h) the chemical symbol for gold, Au, or the standard designation for a gold alloy, including the symbol of the alloying element and a figure in parentheses giving the mean content of that element expressed as a mass fraction in percent to one decimal place;

i) a number giving the minimum local thickness requirement for the gold or gold alloy coating in micrometres;

j) for double and multilayer gold coatings, repeat h) and i), followed by a solidus (/), for each subsequent gold or gold alloy coating required.

5.3 Designating the basis material

The basis material shall be designated by its chemical symbol or the chemical symbol of its principal constituent if an alloy, for example:

Fe for iron and steel;

Zn for zinc alloys;

Cu for copper and copper alloys;

Al for aluminium and aluminium alloys.

In the case of non-metallic materials, the letters NM shall be used.

A specific alloy shall be identified by its standard designation, for example its UNS number or the local, national, equivalent placed between the symbols < >.

For example, Fe<G43400> is the UNS designation for a particular high-strength steel (see Reference [5] in the Bibliography).

5.4 Designation of heat treatment requirements

The heat treatment requirements shall be in brackets and designated as follows:

a) the letters SR for stress relief heat treatment prior to electroplating, the letters ER for hydrogen embrittlement relief heat treatment after electroplating, and the letters HT for heat treatment for other purposes;

b) in parentheses, the minimum temperature, in °C;

c) the duration of the heat treatment in hours, for example SR(210)1 designates stress relief heat treatment at 210 °C for 1 h.

When heat treatment prior to or after electrodeposition is specified, the requirements shall be included in the designation as shown in the examples (see 5.5).

The structure and composition of gold and gold alloy coatings may be modified and the coating properties substantially altered by heat treatment. Designers should be aware of these effects before specifying gold coatings on high-tensile-strength basis material.

5.5 Examples

A pure gold coating, Au, with a minimum thickness of 5 µm on nickel-electroplated steel, Fe/Ni, will have the following designation:

Electrodeposited coating ISO 27874 – Fe/Ni/Au5

An alloy coating containing 98,0 % gold and 2 % silver, AuAg(2,0), with a minimum thickness of 5 µm on a zinc alloy, Zn, with copper and nickel undercoats will have the following designation:

Electrodeposited coating ISO 27874 – Zn/Cu/Ni/AuAg(2,0)5

An alloy coating containing 99,5 % gold and 0,2 % nickel, AuNi(0,2), with a minimum thickness of 0,5 µm deposited over a pure-gold coating, Au, with a minimum thickness of 1 µm on a Cu alloy will have the following designation:

Electrodeposited coating ISO 27874 – Cu/Au1/AuNi(0,2)0,5

A pure-gold coating with a minimum thickness of 5 µm, Au5, deposited over a copper undercoat that is 5 µm thick, Cu5, on a steel that has an ultimate tensile strength of 1 200 MPa and is heat-treated prior to electroplating for stress relief at 200 °C for 3 h, SR(200)3, and after electroplating to reduce the risk of hydrogen embrittlement at 190 °C for 12 h, ER(190)12, will have the following designation:

Electrodeposited coating ISO 27874 – Fe/SR(200)3/Cu5/Au5ER(190)12

The designation describes the heat treatment and electroplating steps in the order in which they are performed. The standard designation of the basis material could be placed after the chemical symbol, Fe, in the above example. It is especially important to know the standard designation of a metal or alloy that is difficult to prepare for electroplating and that is susceptible to hydrogen embrittlement.

6 Requirements and test methods

6.1 General

Gold and gold alloy coatings normally consist of a single layer of gold metal, usually with a strike undercoat of unspecified thickness, but double or multilayer coatings may be specified by the purchaser [see 4.2 c)].

6.2 Appearance

Although this International Standard does not specify the condition, finish or surface roughness of the basis material prior to electroplating, the appearance of electroplated gold and gold alloy coatings depends on the condition of the basis material (see the Bibliography for surface preparation methods). Over the significant surface, the electroplated article shall be free from clearly visible blisters, pits, roughness, cracks and uncoated areas other than those that arise from defects in the basis material. The electroplated article shall be free from extraneous soil and mechanical damage. On articles where a contact mark is unavoidable, its position and extent shall be specified by the purchaser [see 4.1 d)].

In the case of selectively plated articles, the degree and extent of discoloration at the boundary between the areas that have been electroplated and those that are not electroplated shall be specified on the product drawing.

If required, a preliminary sample with the required standard of finish shall be supplied or approved by the purchaser [see 4.1 e)].

The types of article which are selectively electroplated with gold are commonly also selectively electroplated with other metals, such as a nickel undercoat or solderable tin alloy coating. Agreements on visual standards will thus extend to all such areas and boundaries. It is therefore essential that such parameters be specified on the product drawing.

6.3 Thickness

The thickness of the coating specified in the designation shall be the minimum local thickness. The minimum local thickness of the coating shall be measured within the reference area or at a site specified on the component drawing. The minimum thickness of the gold or gold alloy coating shall be that specified by the purchaser.

One or more of the methods given in Annex B shall be used to measure the thickness of the gold or gold alloy coating.

A profile of the minimum-thickness distribution may alternatively be specified on suitably prepared drawings.

Thicknesses of gold and gold alloy coatings commonly specified for electrical, electronic or engineering applications are given in Table 1.

Table 1 — Examples of commonly specified thicknesses of gold and gold alloy coatings for various applications

Application	Minimum thickness µm
Solderability retention, low-reliability electrical contacts	0,1
Medium-reliability electrical connector and switch contacts (electroplated acid gold alloy)	0,25
Semiconductor bonding (pure gold)	0,5
High-reliability consumer electrical contacts	0,75
High-frequency devices and waveguides (pure gold)	1,0
High-reliability electrical contacts for safety-critical applications	2,5 or 5,0