Standards Topics

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Porosity & Porosity Test Specifications Part 1

Everybody talks about porosity, but hardly anybody does anything about it. Before discussing the subject, however, perhaps we should define *pores* and *porosity*.

Early Definitions

In the beginning, a pore was thought to be a vertical hole in a plated coating. It was considered to be the result of either a nonconductive inclusion in the substrate, or an adherent hydrogen gas bubble generated during the plating process that masked the surface, preventing plating underneath it. Porosity was defined as the number of pores for a given area.

Research Reveals Additional Types of Pores

Researchers later identified, in addition to the vertical pore: The inclined pore, the convoluted pore and the branched pore. Also identified was the "masked" pore and its three varieties:

- The sealed-at-the-surface pore, which starts at the substrate surface and gradually closes over;
- The completely hidden pore, which starts after plating initiates and then closes over;
- The sealed-at-the-base pore, which starts out like the hidden pore, but never closes over.

I have often referred to these types of pores as "potential pores," because although the coating may pass initial porosity tests, the pores may appear after the coating has been in service a relatively short period of time.

Also identified were pores arising from defects in the basis metal and pores caused by local shielding, such as oil droplets, suspended particles in the bath, and hydrogen gas bubbles.

Gross Defects & Intrinsic Porosity

Most recently, porosity has been defined as a discontinuity that includes cracks, micro-holes, pits, scratches, or any other opening in the coating surface that exposes a different underlying metal.

One of those rare individuals who not only talks about porosity, but actually does something about it is Dr. Simeon J. Krumbein of Amp, Inc. (previously a professor at Brooklyn Polytechnic Institute). He is a member of ASTM Committee B08, and chairs Subcommittee 8 on Engineering Coatings.

Prof. Krumbein has long held that the "discontinuity" definition is not quite right. He believes that the general term "porosity" has two components: Gross defects and intrinsic porosity.

Gross Defects

Gross defects are those breaks in the coating that expose relatively large areas of underlying metal to the environment. Gross defects include those produced by mechanical damage and wear, in addition to as-plated large pores (with diameters an order of magnitude greater than intrinsic porosity) and networks of microcracks.

Such large pores and microcrack networks indicate serious deviations from acceptable coating practice (*e.g.*, dirty basis-metal substrates and contaminated or out-of-balance plating baths).

Intrinsic Porosity

Intrinsic porosity is the "normal" porosity present, to some degree, in all commercial thin platings (*e.g.*, precious metal coatings for engineering purposes), and it will generally follow an inverse relationship with thickness.

Intrinsic porosity is primarily the result of small deviations from ideal plating and surface preparation conditions. Scanning electron microscope (SEM) studies have shown that the diameter of such pores, at the plating surface, is of an order of 1–2 micrometers, so only small areas of underlying metal are exposed to the environment.

Prof. Krumbein's research showed that some porosity test solutions, because of factors such as viscosity, would react with and reveal gross defects and mechanical damage to the coating, but were unable to enter microscopic pore holes and react to reveal them.

His most recent contribution to porosity testing, which is based on this phenomenon, is the preparation of a new ASTM specification—Standard Test Method for Gross Defects and Mechanical Damage in Metallic Coatings by Polysulfide Immersion. The specification is currently in the final balloting stage in ASTM. This method is suitable for gross defects and mechanical damage (including wear-through) in coatings of gold, nickel, palladium, tin and tin-lead, or their alloys, on substrates of copper and copper alloys.

Soon to follow will be Standard Test Method for Gross Defects and Mechanical Damage in Metallic Coatings by the Phosphomolybdic Acid (PMA) Method. This method will be suitable for coatings of gold, silver or palladium, where these metals comprise the topmost metallic layers over substrates of nickel, copper or copper alloys.

A continuation of this discussion on porosity tests will appear in next month's "Standards Topics" column. *P&SF*