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Ion Plating Technique Improves Thin Film Deposition

The problem:

To develop a thin film deposition technique that keeps the substrate surface clean until the film is deposited, allows extensive diffusion and chemical reaction, and joins insoluble or incompatible materials.

The solution:

An ion plating technique that involves the deposition of ions on the substrate surface while it is being bombarded with inert gas ions. The inert gas ions sputter contaminants from the surface by atomic ejection. The film material is then thermally evaporated into the positive glow region of the gas discharge and is deposited onto the substrate surface at a rate faster than that of the sputtering removal of material from the surface. Therefore, the film is deposited onto an atomically clean surface. The ion bombardment creates a highly defected surface, thereby increasing the number of nucleation sites, which enhances diffusion, and permits a pseudodiffusion with insoluble materials. The high-energy flux raises the surface temperature, which also aids diffusion and promotes chemical reaction.

How it's done:

The substrate is made the cathode of a high-voltage dc circuit, and the filament for the evaporation of the material to be deposited forms the anode. A dc gas discharge is established by admitting inert gas into the system and applying a high potential between the electrodes. Typical deposition parameters for ion plating are 5000 volts applied potential at 0.5 ma/cm^2 cathode-current density using argon gas. Cleaning time is approximately 30 minutes, and evaporation times are several minutes, although evaporation rates vary with different film materials. Deposited film thicknesses are on the order of 10,000 to 250,000 Å. Bulk substrate temperature rise is 250° to 350°C with a power input of 2.5 watts/cm^2.

Cleaning of the substrate by inert gas ion bombardment removes essentially all of the oxygen from metals such as aluminum, which form tenacious bonds with oxygen. An oxygen-inactive metal, like gold, can then be deposited, forming a gold–aluminum intermetallic compound.

By varying the technique, this ion plating process can be used to plate metal films onto nonmetallic substrates. Gold, for instance, can be deposited on silica by adding oxygen to the gas discharge, forming an oxide–gold–oxygen interface on an extensively etched silica surface. More reactive metals may be bonded to ceramics successfully in an oxygen atmosphere. High-energy metal ions impinging on the surface can often penetrate several lattice sites into the substrate surface. This penetration permits the formation of a pseudo-diffusion type of interface, even if the materials are mutually insoluble. A silver–iron interface, for example, was formed with a film thickness of approximately 25,000 Å; the ion plated substrate did not rupture, even with a 42 percent elongation.

Notes:

1. Low molecular weight organic materials are often difficult to bond. Their surfaces may, however, be made bondable by oxidation or ion bombardment. These surface treatments may allow many structural plastics to be coated with a variety of metals, thereby extending their usefulness.
2. The surfaces of brittle materials may be hardened by micropeening with very fine particles or by removing the surface containing microcracks by chemical etching or sputter cleaning.

(continued overleaf)

3. Inquiries concerning this innovation may be directed to:
   Sandia Office of Industrial Cooperation
   Org. 3413
   Sandia Corporation
   Post Office Box 5800
   Albuquerque, New Mexico 87115
   Reference: B68-10212

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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