

Electroless Plating: Fundamentals and Applications

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Many texts have been written on surface finishing over the years that deal with electroless deposition as a sidelight. Through the talents and efforts of Glenn Mallory and Juan Hajdu, a comprehensive text, entitled *Electroless Plating: Fundamentals and Applications*, is available through AESF Headquarters. The editors have combined the efforts of 27 contributing authors to produce a wide-ranging text that covers both fundamental and applied aspects of the subject. Published by the AESF, the book was first introduced at SUR/FIN[®] '91—Toronto.

Electroless Nickel

Half of the text is devoted to all aspects of electroless nickel deposition. About one-sixth covers electroless copper deposition. The remainder deals with other metals deposited by electroless means in commerce, including gold, silver, cobalt and the platinum group metals. There are chapters dealing with specialized topics such as electroless alloy deposition, composite electroless plating, plating on plastics, general chemical deposition (including immersion and contact deposition) and waste treatment.

A major portion of the book deals with electroless nickel because of the experience with it, and its importance, in a number of disparate technologies. Mallory's two chapters on the fundamental aspects of electroless nickel actually serve as a treatise on the fundamentals of electroless plating in general. The material is discussed in terms of the functions and mechanisms involved with the bath components:

- (1) The source of nickel ions,
- (2) The reducing agent,
- (3) The completing agents, and
- (4) The stabilizers or inhibitors.

Both phosphorus- and boron-containing nickels are considered. Next, the fundamental effects of variables on the process are considered. Acid hypophosphite,

alkaline hypophosphite, borohydride and dimethylamine borane systems are discussed in terms of resultant deposit composition and deposition rate.

The discussion also considers reaction kinetics and the effects of reaction by-products on continuing process characteristics.

Along more applied lines, troubleshooting of electroless nickel is discussed in terms of solution chemistry, solution contaminants, substrate preparation and equipment considerations. A useful chart for the more common operational problems is included.

A thorough discussion of electroless nickel properties is provided. The structure of nickel-phosphorus and nickel-boron deposits is discussed. Mechanical properties such as tensile strength, elongation and hardness are considered along with the physical properties important for various applications, density, electrical, thermal and magnetic properties. Of particular note is the good coverage given to corrosion and wear—two very important areas of concern for electroless nickel. The authors of this chapter have managed to incorporate a large number of literary contributions quite effectively.

Another practical consideration covered is equipment design, including tanks, heaters, filters and the devices necessary to handle air, water and replenishing chemicals without contaminating everything. Quality control is considered both from the standpoint of process management and charting, and also in terms of the actual chemical and physical test methods for controlling the process and meeting specifications.

Substrate preparation is of particular importance because of its role in initiating the deposition process. This chapter is organized by substrate type, including iron and ferrous alloys, aluminum and its alloys, other metals and non-metallic substrates (such as glass and ceramics). Plastic substrates, which occasionally use electroless deposits other than nickel,

were deemed sufficiently important to cover in a separate chapter.

Engineering applications of electroless nickel are covered. There are interesting discussions on the uses and properties of interest in the aerospace, automotive, chemical processing, oil and gas, and mining industries. Applications in the electronics industry merit a separate chapter. Typical process cycles, controls and tests for printed wiring boards and components are included.

Electroless Copper

Electroless copper is covered in two chapters. The first discusses fundamental aspects, including composition, mixed potential theory, kinetics and catalytic mechanisms. Properties are also covered here.

The second chapter deals with the major application for electroless copper—the manufacture of printed wiring boards. The intent here is not to give a lesson in board manufacture. Rather, the emphasis is on the role of electroless copper in the manufacturing process. The critical importance of electroless copper to the fabrication of plated through-holes is stressed.

With many general principles of electroless plating covered in the nickel and copper chapters, it would seem that the other metals might be slighted. But such is not the case. The electroless deposition of gold and its alloys is treated thoroughly in light of its importance in electronic applications. The chapter covers the many successful pure gold bath formulations and their applications, as well as alloys with silver, copper and tin. The chapter on the electroless deposition of the platinum group metals emphasizes palladium and also discusses platinum, ruthenium and rhodium systems. The plating process and the reaction mechanism of electroless silver deposition is covered in its own chapter. Finally, electroless cobalt and its alloys merit two chapters—the first on properties (em-

phasizing the magnetics) and the second on the process.

Other Categories

There are a number of other important subjects covered that are not easily categorized. A general discussion of the electroless plating of alloys considers ternary and quaternary systems resulting from the incorporation of other elements into the common electroless plated deposits. The incorporation of fine particulate to form electroless composites receives good treatment in another chapter. Emphasis is placed on wear and friction.

Plating on plastics is covered well, with emphasis given to the wide use of ABS materials. The importance of good molding practice and the preparatory steps prior to electroless deposition in promoting adhesion are stressed. The thermal cycling and adhesion testing germane to plated plastics is discussed, as is the use of plated plastics in electromagnetic interference shielding (EMI) applications.

While the book title implies the traditional autocatalytic deposition processes brought about through reducing agents in the solution, the authors point out early that deposition without current also includes other chemical plating processes, including immersion plating. One chapter, entitled "Chemical Deposition of Metallic Films from Aqueous Solutions," cov-

ers these considerations. It also discusses the lost process called "contact," or galvanic plating.

Waste Treatment

The book would not be complete without a review of waste treatment technology for electroless processes. The problems unique to electroless solutions, such as chelators and stabilizers, are stressed. Emphasis is placed on waste minimization as the first step in reducing waste treatment needs. In addition to conventional precipitation methods, advanced treatment technologies, such as ion exchange and electrolytic recovery are discussed.

The book is typeset in an easily readable type font, at least for this bifocal-equipped reviewer. The graphics and diagrams are relatively large. These features add to the clarity and understanding of the materials.

While I might quarrel with the order in which some of the topics are discussed (a matter of personal preference), I cannot quarrel with the importance and quality of this book. It is one that every surface

engineering professional should have in the library. I highly recommend it. •

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