ELECTROLESS NICKEL FOR THIN-FILM MAGNETIC MEMORY DISCS

ABSTRACT

Rigid aluminum discs plated with a thin, cobalt-based magnetic medium offer increased memory storage capacity for advanced computers. In one successful process cycle, the cobalt is plated over a special electroless nickel with non-magnetic characteristics and other desirable properties that enhance the cobalt film's durability and magnetic performance. In the paper, disc technology is reviewed, and the special electroless nickel is described in terms of its required deposit characteristics, its bath parameters and its plating cycle.

INTRODUCTION

Computers must have memory storage capacity to function properly and to be programmable. An increase in storage capacity means the computer can be used for a larger number of functions and can deal with greater amounts of information. The ability to store a large amount of permanent information is an essential requirement of today's advanced computer.

There are a number of different types of storage devices used by computers. One that has benefited from technical advances that have significantly increased its storage capacity is the magnetic recording disc. This paper reviews the technology of flexible and rigid discs; discusses the Winchester drive; compares the performance of iron-oxide memory media to cobalt-based, thin-film media; and details bath parameters, deposit properties and plating cycles of the special electroless nickel used as an undercoat for the cobalt medium.

FLEXIBLE DISC

The flexible (floppy) disc, which was introduced in 1970, is a popular, low-cost memory storage device. It is made of Mylar plastic that is coated with a magnetic medium, usually iron oxide. A read/write head reads and records information on the magnetic medium in essentially the same way a tape recorder head records information on a magnetic tape. The floppy disc system works quite well, but it has its limitations. The read/write head touches the lubricated surface of the disc as it rotates, causing wear. The disc's speed is limited to about 300 rpm, thus limiting the speed that information can be transferred to and from the disc's surface. The Mylar plastic tends to expand and contract with temperature changes, limiting track density to about 96 tracks per inch. This track density limitation means that an 8-inch floppy disc can store only about 500,000 characters, which is approximately equivalent to 250 typed pages.

WINCHESTER DRIVE (RIGID DISC)

The introduction of the Winchester drive with its sealed head/disc assembly was the next logical step in increasing memory storage capacity. Pioneered by IBM, the Winchester drive originally contained two 14-inch discs, each capable of storing 30 megabytes of information. It was referred to as the 30-30 and came to be known as the Winchester in honor of that company's famous rifle. Since then, advances in Winchester drive technology have resulted in smaller and less expensive units. Today, there is a Winchester drive unit for desk-top computers) that uses one 5 1/4-inch rigid disc capable of storing 5 megabytes of information. This is equivalent to about 2,500 typed pages, or ten times the memory capacity of the floppy disc.

Generally, the Winchester drive unit uses rigid, polished aluminum discs with thin coatings of iron oxide. The metal is less affected by temperature variations than the plastic floppy disc and so the tracks can be placed closer together. Track density is about 250 tracks per inch. The Winchester's head does not ride directly on the iron-oxide coating as the floppy disc's head does. Instead, the head flies about 20 millionths of an inch above the coating on a cushion of air created by the disc's rotation. The disc can spin at 3600 revolutions per minute, more than ten times faster than the floppy disc. Thus, the Winchester drive can handle information faster and its reliability is greater because the enclosure is sealed.

The relatively thick iron-oxide coating can present a problem to the low-flying head if the coating's surface is not perfectly smooth, i.e., inadvertent head contact could result. Also, there is the possibility that minute particles on the head can tear magnetic material loose, resulting in a chain reaction of loose particles and a head crash. When this occurs, the iron-oxide coating is destroyed and the memory is lost.

THIN-FILM MEMORY DISC

The memory storage industry is moving rapidly to a thin-film, cobalt-based medium because it offers significant advantages over the thicker iron-oxide coating. One
thin-film plating technology that shows exceptional promise involves the use of a special non-magnetic electroless nickel-phosphorus undercoat. After proper surface preparation, the rigid aluminum disc is plated with the special electroless nickel to a thickness of about \( 1/2 \) mil (12.5 micrometers), polished to a high finish, and then coated with an ultrathin layer of a magnetic recording medium, such as electroless cobalt-phosphorus, electroplated cobalt-phosphorus, or evaporated cobalt-chromium alloy. Unlike the floppy disc, the thickness of the cobalt medium is only 21/2 to 5 millionths of an inch and its surface is smoother and more durable. Therefore, the head can fly very close to the surface an important factor in increasing the disc's storage capacity. An equally important factor contributing to the disc's increased storage capacity is the inherently high coercivity of the cobalt film.

Although thin-film memory disc technology is not new, the demand for the disc's special properties has only recently accelerated. The discs are capable of very high linear density — 25,000 bits per inch or more. They are durable, are able to withstand head contact, and are resistant to corrosion. Winchester drives using thin-film discs now can be made small enough and light enough to be held in the palm of a hand. Of course, small, lightweight units are more subject to accidental bumps, vibrations and jars, which are major causes of head crashes.

**ELECTROLESS NICKEL UNDERCOAT**

The electroless nickel-phosphorus undercoat serves as a base for the cobalt memory medium. In this respect, the electroless nickel deposit must exhibit certain properties and characteristics that enhance the cobalt film's durability and magnetic performance. Importantly then, the electroless nickel deposit must be a high-quality coating; it must be highly corrosion resistant; and it must be non-magnetic as-deposited and must remain non-magnetic even when exposed to elevated temperatures or to aging.

**Corrosion resistance**

Since aluminum is anodic to nickel, galvanic corrosion of the aluminum substrate may occur if the substrate is exposed to corrosive elements through the pores of the nickel undercoat. Two inherent properties of most electroless nickel-phosphorus deposits are their low porosity and high resistance to chemical attack. However, in thin-film disc application, these properties must exceed the norm, i.e., the nickel-phosphorus deposit must be exceptionally pore-free and have superior corrosion resistance.

**Deposit Finish**

Another important requirement of the electroless nickel undercoat is that it be capable of being polished to a very high finish. This means that the deposit must be completely free of all defects, including surface roughness and pits. Defects in the surface or irregularities of any kind in excess of one-millionth of an inch can cause head crash or defective recording.

**Magnetic Properties**

There are two types of magnetism to consider in the memory disc system: "hard magnetics" and "soft magnetics." Any substance that retains its ferromagnetism after exposure to a magnetic field is said to have hard magnetic properties. On the other hand, any substance that becomes magnetic while in a magnetic field but loses its magnetism when the field is terminated is said to have soft magnetic properties. Read/write heads require soft magnetic materials so that rapid magnetic switching can occur. The disc's recording medium requires hard magnetics so that permanent magnetic domains can be produced.

All materials in close proximity to or in contact with these magnetic materials must be non-magnetic. This is especially true of the electroless nickel undercoat, which must be non-magnetic as-deposited and remain non-magnetic even when exposed to elevated temperatures. As examples: the electroless nickel coating may be heat treated to temperatures up to 250°C for one hour to promote its adhesion to the aluminum surface; or, the electroless nickel coating may be heated to temperatures up to 330°C for two minutes to passivate its surface before deposition of the cobalt medium; or the cobalt medium may be heat treated to provide a lubricating cobalt-oxide surface film.

Why is it important that the electroless nickel deposit be non-magnetic and remain non-magnetic? Because the electroless nickel undercoat is exposed to the magnetic field used to record data on the cobalt medium. If the undercoat retains any magnetism, a change in recording and erasing energy would be required. Retained magnetism in the electroless nickel undercoat could cause the recording signal to be weaker or could erase the recording signal, depending on the strength of the retained magnetism. Even a small amount of retained magnetism results in a loss of signal and in noise.

**ELECTROLESS NICKEL PLATING BATH**

The composition and characteristics of the electroless nickel bath and the attention paid to its operation are important factors in obtaining the desired properties and quality of the electroless nickel undercoat.

Non-magnetic electroless nickel deposits tend to be high-phosphorus and more nearly amorphous than other electroless nickel deposits. The time and temperature required to precipitate the nickel-phosphorus intermetallic alloy, which results in hardening the deposit, also causes magnetic domains to form. Thus, a deposit that is initially non-magnetic could be transformed into a magnetic deposit. Therefore, the composition of the plating bath must be such that it produces a non-magnetic deposit that resists changes in structure at elevated temperatures.

The selection of chelating agents for the electroless nickel plating bath is important. To a large extent, the deposit's magnetic character is determined by the combination of organic complexion agents in the plating solution.

A non-magnetic deposit may be achieved from many electroless nickel baths by operating the baths at reduced pH values, i.e., from 4.5 down to 4.1. However, low-pH baths plate very slowly, thus limiting the production rate. Also, they consume sodium hypophosphite at a higher rate, resulting in more frequent dumping of the bath due to excessive buildup of phosphate ions. Adjusting the formula by careful selection of chelating and complexing agents is preferred, so that reasonable plating rates can be maintained along with efficient, long-lasting solutions.

A successful plating bath that produced a high-quality nickel-phosphorus deposit capable of withstanding high temperatures and aging without becoming magnetic, had the following operating parameters:
Bath temperature 192° F 89° C
Bath pH 4.6-4.8
Bath replenishment Automatic chemical feed based on nickel content and pH analyses to maintain bath at near 100% concentrations.

The bath was stable and long lasting and was made up of the purest, cleanest materials available. In addition to these important requirements, special attention was given to filtration to prevent even the smallest particle from causing deposit defects. Filtering was through a 1-micron depth filter, followed by an absolute filter (screen of 0.25 to 0.45 micron. At frequent intervals, carbon filtration was used. The carbon-packed filter was followed, in series, by the microfiltration system previously described.

**PROCESS CYCLE FOR PLATING ELECTROLESS NICKEL ON 5086 ALUMINUM ALLOY**

The surface of the finished disc must be nearly perfect. Therefore, it is mandatory to use a high-quality aluminum alloy with the highest possible finish, and to prepare the surface in such a way that its finish is not destroyed. The alloy used to produce magnetic memory discs is 5086, which is a magnesium-containing alloy. Magnesium tends to congregate at the grain boundaries, providing electrochemical cells that could lead to pitting of the aluminum if severe processing steps were used. Therefore, a mild non-etching alkaline cleaner is required in the initial stage of the preplate cycle. An extremely mild acidic treatment is then used to remove oxide films from the aluminum disc so it can properly receive the zincate treatment. A double zincate treatment provides the best base and the smoothest surface for subsequent electroless nickel plating. In terms of adhesion requirements, a properly cleaned and prepared aluminum disc that is plated with 0.0005- to 0.001-inch (12.5-25 micrometers) of electroless nickel should be capable of being bent double with no cracking or flaking of nickel.

*Typical Process Cycle*

1. Alkaline clean in a mild, non-etch cleaner.
2. Rinse.
3. Acid clean and deoxidize in a mild non-etch cleaner/deoxidizer.
4. Rinse.
5. Zincate 20-25 seconds at room temperature.
6. Thorough rinse.
7. Strip the zinc deposit in 60% by vol. nitric acid (42° Be’).
8. Rinse.
9. Zincate (15 seconds at room temperature). Must be a separate zincate.
10. Thoroughly rinse (double rinse, counter-flow).
11. Neutralize in a solution of 4 oz/gallon (30 g/L) sodium bicarbonate.
12. Rinse (DI water).
13. Electroless nickel plate.

**PROCESS CYCLE FOR PLATING ELECTROLESS COBALT ON ELECTROLESS NICKEL**

A typical process cycle for plating an electroless cobalt medium on the electroless nickel undercoat is as follows:

1. Polish electroless nickel undercoat to a high finish.
2. Clean in a mild alkaline cleaner.
3. Rinse (DI water).
4. Activate. Mild acids are often used (proprietary solutions vary from mild alkaline to acidic solutions).
5. Rinse (DI water).
6. Electroless cobalt plate for 1-2 minutes at a bath temperature of 150-170°F (65 -76°C).
7. Rinse.
8. Dry.
9. Apply lubricant over coating carbon, silicon dioxide, fluocarbons, oxidizing treatments and other processes). This step is optional.
10. Test for magnetic characteristics.

**BIBLIOGRAPHY**


