**ELECTROPLATING TECHNOLOGY;**
**THE IMMENSE IMPACT ON MAGNETIC STORAGE AND ELECTRONICS**

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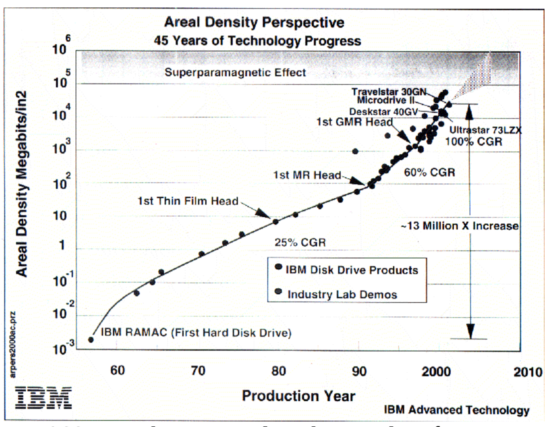
**Introduction**

It is hard to imagine a computer without a magnetic storage disk. The disk is where all the programs reside and where all the information we process is stored. In 1957 IBM introduced to computing the first storage device under the name of RAMAC 305. The system consisted of 50 aluminum disks of 24 inch diameter. The magnetic read and write heads were made of ferrite cores that were hand wound with a thin copper wire. The storage density was 5 million Bytes/sq. in. From the beginning there was an insatiable appetite for more storage and for faster systems.
Figure 1. The rate of growth recording density.




By 1966 it was becoming clear that winding ferrite cores with copper wire was near its limit. Several industrial laboratories initiated work on batch fabrication processes. They used dry processing techniques which were being developed for magnetic thin film memory and silicon devices. These attempts failed because to build magnetic heads it was necessary to build a three dimensional structure. Dry processing and etching were capable of producing only planar structures. Electrodeposition appeared to present an attractive choice if the desired magnetic properties, 3D structure and process integration could be achieved.

**Challenges Facing an Electrochemist**

To an electrochemist the structure presented also tremendous challenges:
1/. Three dimensional structures on a planar surface required selective plating on insulators. This has never been done before.
2/. The insulator required a very thin plating seed layer and plating through resist mask. This was exactly opposite approach to that practiced in semiconductor fabrication where photo resist was used as an etch mask.
3/. For permalloy plating it was necessary to develop a plating solution which would not be sensitive to local variation of the diffusion layer thickness, agitation and current density.
4/. Special plating equipment had to be developed which would assure, uniform current density, diffusion, hence compositional uniformity over a large wafer.
5/. There was no knowledge about long term stability of a permalloy plating solution.
6/. No knowledge how to achieve very smooth vertical walls without discontinuities and imperfections.
7/. Nothing was known about the thermal stability of the permalloy or of the entire integrated structure.
8./ The relationship between the plating parameters-metallurgical structure and the magnetic properties.

**Plated Magnetic Thin Film Heads: *NEW ERA FOR MAGNETIC STORAGE*, quantum jump for Electrodeposition.**

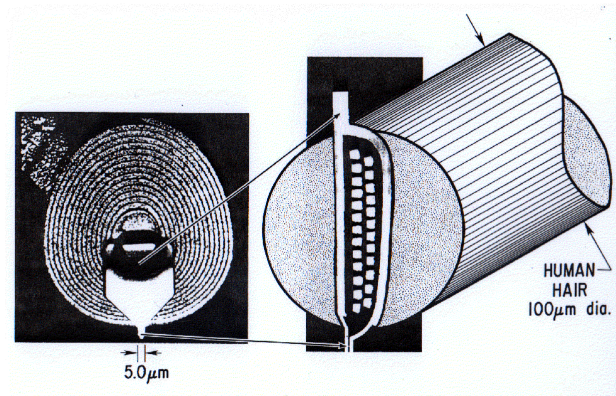



Figure 2. Early Multi-Turn Inductive read-write head.

In the late 1960's and early 1970's researchers at the IBM T. J. Watson Research Center, found solutions to above problems and fabricated first inductive multi-turn read-write heads by electroplating permalloy and copper coils through lithographic masks. It was the invention of: through mask plating technology, new permalloy plating solution, methods of achieving uniform composition and thickness of permalloy, plating through narrow resist frames, of new paddle plating cell, discovery that Novolak photoresist when baked at high temperature becomes high quality dielectric with thermosetting characteristics, which greatly helped integration, and made fabrication of heads possible.

The process technology of plating through mask proved so far to be fully extendable, more than four orders of magnitude from 8 Megabytes/sq. in. in 1979 to 60 Giga bytes /sq. in. today. The cost of a magnetic storage has come down, since 1979, by 4 orders of magnitude, from $10.00 per megabyte to $0.01 per megabyte. The electrodeposition through photo resist masks has helped create an $8 billion thin film head industry.

The ability to build 11 layers, 25 micrometer thick structures with lateral dimensions of two to three microns opened up many new possibilities and started entirely new level of interest in electrodeposition.

**Structure Property Relation In Magnetic Films**

Understanding developed for plating parameters-metallurgical structure-magnetic properties relation for permalloy and NiFeCu alloys in 1970-ies laid the basis for recent tailoring of high magnetic moment CoFeCu, FeNi, CoFeNi, CoFe and others.

**Extension of Plating Through Masks to Electronics**

Plating through masks has now been extended to fabrication of gold plated x-ray lithography masks, thin film packaging, silicon chip carriers, gold bumps, chip to package solder interconnects, to plating of high resolution flex and PC boards, inductors and to variety of high aspect ratio MEMS structures.

**Future**

Without electrodeposition we may have not had today, the ability to record, store, and read back as many as 20 Gigabits of information per square inch, and retrieve this information, residing on a disk thousands of miles away in fractions of seconds. We may have not had the Internet the way we know it today.
After discussion of the impact electroplating technology had in the past, this paper will look ahead, and will point out why electroplating should be considered a technology with a very promising and bright future.