Platinum Media for Data Storage

REPORT FROM MAGNETO-OPTIC RECORDING SYMPOSIUM

The first international conference dedicated entirely to magneto-optic recording, MORIS'91, Magneto-Optic Recording International Symposium, was held in Tokyo, Japan, from 16th to 19th April 1991. The scope of the conference covered a broad range of topics, including current and potential magneto-optic materials, their processing and properties, and the physics and technology of magneto-optic recording. Rare earth alloys are currently used as first generation magneto-optic materials, but platinum/cobalt and palladium/cobalt multilayered thin films show great promise for future use as second generation media. A selection of the papers presented are reviewed here.

The first magnetic storage devices were used in computers about thirty-eight years ago, the most important of these devices being the magnetic disk. The evolution of this magnetic disk technology was outlined in a paper given by Y. Miura of Fujitsu Laboratories Ltd., Kanagawa, Japan. The technology of magnetic disks is still being developed and improved, but ultimately it will be limited by the fact that, to increase the storage density, the flying height of the write/read head above the disk must be extremely low (0.2 μm), and hence the disks must remain fixed within the computer. For magneto-optic recording, the optical write/read head is relatively distant from the disk (1.5 mm), and so the disk is removable. This has the advantage of increased security and ease of data transfer between systems.

The other main advantage of optical based systems is their increased storage density. The amount of data which can be stored on a disk depends on the size of each "bit" of information. In magnetic and magneto-optic recording, this is the size of the magnetic domains "written" on the disk surface. In magnetic recording, the magnetic moments of the domains are horizontal, and their size depends on how close the write/read head is to the surface. In a magneto-optic disk, however, the domains are vertical and can, therefore, be more closely packed. Their size is controlled by the area covered by a laser beam focused onto the surface. The size of this area is governed by the wavelength of the laser: the shorter the wavelength the smaller the area.

The first generation magneto-optic materials to reach the market are amorphous rare earth/transition metal alloys, for example, TbFeCo- and GdTbFe-based compounds. These materials have good magneto-optic properties at the wavelengths of commercially available solid state lasers, that is around 820 nm. In an invited talk on the challenges for future magneto-optic materials, P. F. Carcia from Du Pont Company, Wilmington, U.S.A., and W. B. Zeper and H. W. van Kesteren, Philips Research Laboratories, Eindhoven, The Netherlands, discussed the role of metal multilayers for shorter wavelength recording. By changing the optical wavelength of the write/read laser from 820 nm to 410 nm, the density of stored information can be increased by about a factor of four. Substantial progress has been made recently in generating shorter wavelength, blue laser light by frequency doubling techniques using non-linear optics. However, the Kerr rotation, which is used to read the stored data, is small in the blue region of the optical spectrum for the rare earth/transition alloys currently in use; reducing from 0.27° at 800 nm to 0.14° at 400 nm.

The spectral dependence of platinum/cobalt and palladium/cobalt multilayers shows an increase in Kerr rotation at the shorter wavelengths: 0.20° at 800 nm increasing to 0.35° at 400 nm for multilayers of 9Å Pt/4Å Co. This strongly indicates that these materials could become the second generation magneto-optic media. This effect at shorter wavelengths is enhanced by increasing the cobalt content in the multilayered structure. However, with a greater thickness of cobalt, the perpendicular magnetic anisotropy which controls the vertical nature of the domains, becomes less pronounced. Also, the Curie temperature of the film is increased with increasing cobalt concentration. This would necessitate using a higher laser power to switch the domains during the writing process. One consequence of this is the reduction of signal to noise ratio with repeated write/read/erase cycles, due to heating in the multilayers. Cobalt-rich multilayers suffer more than a 6 dB loss in signal to noise ratio after fewer than 10^4 cycles, whereas a more platinum-rich multilayer suffers no loss after more than 20,000 cycles. The challenge, therefore, is to produce a media with a reduced Curie temperature while maintaining the Kerr rotation.

Work on high density recording on platinum/cobalt multilayers, using a blue laser was also presented by S. Sumi, K. Tanase, Y. Fuchigami and K. Torazawa of Sanyo Electric Co. Ltd., Gifu, and S. Tsunashima and S. Uchiyama of Nagoya University, Japan. Structures with 18 double layers of 13Å Pt/4Å Co were magnetron sputtered onto silicon nitride and tested using an argon laser with a wavelength of 458 nm. The film had a Curie temperature of 300°C (the writing temperature of rare earth based media is approximately 200°C) and the Kerr rotation was 0.67°. Stable magnetic domains as small as 0.2 μm could be sustained on the film. The magnetic and recording characteristics of these multilayers make them very attractive for high density recording.

There are many factors to be considered when optimising a multilayered structure for magneto-optic recording. In order to reduce the vast amount of experimental work required in such a task, computer modelling is often used to predict some of the characteristics of a potential magneto-optic film. This topic was considered by several speakers. Not only are the mathematical equations used in the model important, but it is also necessary to understand the optical, magnetic and magneto-optic properties of the constituent layers. The model can then be validated by comparison between the predicted results and the properties of a multilayered stack.

Work in this field formed the basis of a paper presented by J. W. Stuart of Johnson Matthey, on work by R. Carey, D. M. Newman, P. A. G. Sandoval and B. W. J. Thomas of Coventry Polytechnic, and P. J. Grundy and E. T. M. Lacey of Salford University, U.K. The aim of this work was to measure the properties of thin films and multilayers in order to use the appropriate material parameters in a model of multilayered structures. Structures with 8Å Pt/3Å Co, with total thicknesses ranging from 11 to 44 nm, were prepared by DC sputtering onto glass substrates. Measurements were made over a wavelength range of 500 to 800 nm.

The saturation magnetisation of the films containing cobalt were measured with a vibrating sample magnetometer and showed a linear dependence of magnetisation with total thickness of cobalt as expected.

The optical and magneto-optic properties of the multilayered films had superior properties to those of the single films of equivalent thickness, showing the advantageous effect of the multilayered structure. The optical properties of the multilayers and of single layers of platinum and cobalt showed interesting results for the thinner samples. Above 20 nm thickness, the optical constants n and k (the real and imaginary parts of the refractive index) were fairly constant but were reduced in the thinner films. Comparing the multilayered films with the single films, a 10 double layered stack containing a total of 3 nm of cobalt had much larger optical constants ($n = 2.2$ and $k = 4.3$) than the 3 nm single layer of cobalt ($n = 0.5$ and $k = 2.0$). Similar results were obtained from the magneto-optic measurements.

It must be noted that the calculations used for these results treated the multilayered structure as a homogeneous film. The next stage of this work will be to use the properties of the individual layers in the calculations. However, it can be seen from these results that the measurements on the very thin layers would not give a satisfactory answer. Neither is it reasonable to expect that the properties of the bulk materials could be used to predict those of very thin layered structures. In order to resolve these questions, this work is continuing at Coventry Polytechnic and at the Johnson Matthey Technology Centre.

Computer modelling was described in a paper by T. W. McDaniel of IBM, San Jose, U.S.A., and W. A. McGahan and J. A. Woollam of the University of Nebraska, U.S.A. They compared the properties of three magneto-optic materials over a 300 to 800 nm wavelength range: a 15 × (10Å Pt/3Å Co) platinum/cobalt multilayer, TbFeCo and BiDy-substituted FeGa-garnet. At 800 nm the Kerr rotations for the platinum/cobalt, TbFeCo and garnet were 0.165°, 0.209° and 0.128°, respectively. However, at the lower wavelengths platinum/cobalt had superior properties, although no figures were given. Garnets also look promising at lower wavelengths if the noise due to grain size can be eliminated. This model did not include the thermal response of the media and was not confirmed with experimental data.

The properties of the substrate used to support the recording film must be taken into account when considering the ease of manufacture and the effect on the properties of the film itself. J. G. Barnes, J. M. Bradshaw and I. Molyneux of Pilkington, Lathom, U.K., discussed the properties of glass, polycarbonate, polyolefine and aluminium. One of the main advantages of glass is its high service temperature of 400°C, compared with 130°C for the polymers. This, together with its low thermal expansion (95×10^{-7}/°C) and low absorption properties, make it attractive for use in data storage. However, it is more than twice as heavy as the polymer substrates and requires a more complex manufacturing process. Pilkington are currently developing a direct pressing technique for the bulk manufacture of pre-grooved glass disks.

The condition of the substrate during processing will also have an effect on the final recording media. S. Shiomi, T. Miyauchi and M. Masuda of Mie University, Tsu, and S. Yahagi of Daido Steel, Nagoya, Japan, presented a poster on the effect of substrate heating on the perpendicular magnetic anisotropy of platinum/cobalt multilayered films. For a multilayered structure of 30 × (10Å Pt/3Å Co) deposited onto glass, the anisotropy was maximised when the substrate was heated to 130°C. By comparing the bulk and interface anisotropies it was concluded that moderate substrate heating makes the interface between the layers sharper.

The effect of applying an electric bias to the substrate during the deposition process was discussed by H. Tanimoto, M. Nawate, S. Honda and T. Kusuda of Hiroshima University, Japan. Platinum/cobalt multilayers were sputter deposited onto water-cooled glass substrates, with an applied bias ranging from 0 to −70 V. The application of a bias had little effect on the saturation magnetisation and perpendicular magnetic anisotropy but the coercivity of the multilayers reduced substantially; from 1.2 kOe with no bias to 60 Oe when −30 V was applied. From X-ray diffraction analysis it was concluded that a small bias promoted sharper interfaces between the individual layers. However, alloying at the interface was induced at the higher bias fields. Transmission electron microscopy studies showed a columnar structure in films produced with no bias, which becomes vague and disappears in films produced with increasing bias. Domain patterns, studied using the Bitter method (a 0.1 μm magnetic colloid on the sample surface), confirmed these observations.

In conclusion, this was a very interesting conference which covered a wide range of topics which cannot all be considered in the scope of this article. As summarised by Y. Aoki of Sony, Atsugi, Japan, magneto-optic media have a large role to play in the data storage industry of the future. Magneto-optic media are currently available with over 150,000 units (using 5.25 inch disks) having been sold worldwide; 50 per cent in U.S.A., 35 per cent in Japan and 15 per cent in Europe. It is expected that 3.5 inch disks will be introduced within the next year with over 200,000 units in use by 1992. Magnetic disks and solid state memories may still be used for fast data processing in mainframe computers but magneto-optic storage is expected to replace the floppy and hard disks in personal computers and microcomputers by 2000. J.W.S.

The Platinum Market in 1990

The Platinum Yearbook 1991

BY B. H. NATHAN, Woodhead Publishing/Metal Bulletin, Cambridge, 1991, 153 pages, ISBN 1-85573-045-6, £95.00

The Platinum Yearbook sets out to provide a reference to events in the markets for platinum group metals during 1990. It contains a description of the evolution and operation of the metals markets, prefaced by a concise history of the platinum metals, from the earliest decorative applications of platinum to the isolation of the other five platinum group elements during the nineteenth century, and on to the growth of their major modern applications.

As the managing director of Ayrton Metals, one of the longest established platinum dealers in London, Brian Nathan is well qualified to review the features of the platinum markets of the world and to explain the basic practice of dealing in the platinum group metals. His account of how the markets work is comprehensible, and avoids entangling the reader in the deeper complexities of trading strategems.

Indeed, the principal value of the book lies in its description of the mechanics of the London and the New York markets, its clarification of some of the mystique which surrounds traders, their colloquialisms, and its discussion of the techniques of trading such as "stops", options, charts and arbitrage, which do so much to influence the pattern of platinum metals prices in the short term.

Half of the book is devoted to an extensive review of monthly developments in the markets for the platinum metals, including the economic, political and fundamental supply and demand factors which were of influence during 1990. Access to key events and features described in the text is simplified by a comprehensive and well planned index, while the review is supported by records of the daily movements of platinum and palladium prices in London and New York. The provision of statistics to compare the trading activities in the New York and Tokyo futures markets might be of use in future editions.

As the first in what is intended to be an annual series, the Platinum Yearbook sets out an attractive stall of information. Junior dealers and commentators on the platinum group metals should therefore find it a helpful guide to dealing in the platinum group metals and a useful source for details of price changes during the year 1990. J.S.C.

Iridium Oxide Device for Coulombic Titrations

When determining the acidity or basicity of a solution by coulombic titrations, an actuator electrode is positioned close to the pH sensitive gate of an ion sensitive field effect transistor. The ISFET acts as the indicator electrode to establish the equivalence point in the titration. However, in this system, the operating potentials of the actuator electrode are such that any other redox couple in the solution, or any chloride ions present, will interfere.

Now, however, an all iridium oxide sensor-actuator system has been proposed by researchers at the University of Twente, The Netherlands, and tested for such titrations (W. Olthuis, J. C. Van Kerkhof, P. Bergveld, M. Bos and W. E. Van Der Linden, *Sens. Actuators B*, 1991, **4**, (1&2), 151–156). Since the reversible redox reaction at an iridium oxide electrode functions at a favourable potential, it is suitable for use as the actuator electrode, with a pH sensitive iridium oxide sensor determining the equivalence point. Such a system eliminates interference from any chloride ions present. The preparation of this system is reported to be easier than the preparation of conventional ISFET-based devices.

The authors go on to describe a new current-pulse method of producing iridium oxide where the growth parameters are independent of the pH of the growth solution.