



## **SNMS** **Sputtered Neutral Mass Spectrometry**

# **Depth Profile of Hard Drive Platter**

### **Summary**

Sputtered Neutral Mass Spectrometry is ideally suited to the analysis of thin films where composition, thickness and interface condition can be determined. In this example a hard drive platter is analyzed, showing both the thin and thick layer coatings.

### **Introduction**

Despite development of flash silicon memory and optical drives, magnetic hard disks remain the mainstay of the data storage industry, providing high speed access and high reliability.

Modern drives comprise a number of circular platters of either aluminium or glass construction, onto which are deposited magnetic and non-magnetic layers.

The general construction of a disk platter is shown in figure 1. In use, the read/write head is separated from the disk surface by a cushion of air generated by the spinning action of the platter. Uppermost on the platter surface is a thin polymer layer which

Manufactured in England by:

HIDEN ANALYTICAL LTD  
420 Europa Boulevard, Warrington, WA5 7UN, England  
t: +44 (0) 1925 445225 f: +44 (0) 1925 416518  
e: [info@hiden.co.uk](mailto:info@hiden.co.uk) w: [www.HidenAnalytical.com](http://www.HidenAnalytical.com)

provides a low friction surface in case the disk head makes contact. Beneath this is the magnetic layer onto which the data are written. The fine magnetic domains of the data layer are separated from the thicker magnetic base by a non-magnetic barrier. In order to accommodate the highest data density the magnetic domains in the data layer must be as small as possible, thus the base layer serves to complete the circuit (shown as the arrowed line) and confine the field to the region of the read / write head only.

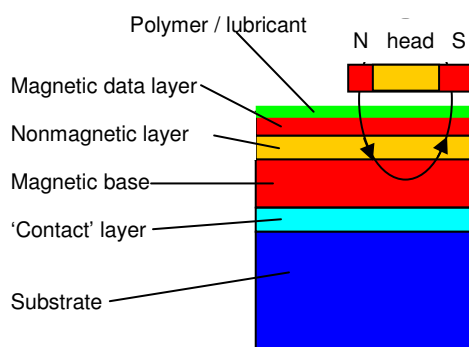


Figure 1 Typical platter cross section

Figure 2 shows the disk platter installed in a drive with the head and motor assembly prior to analysis.

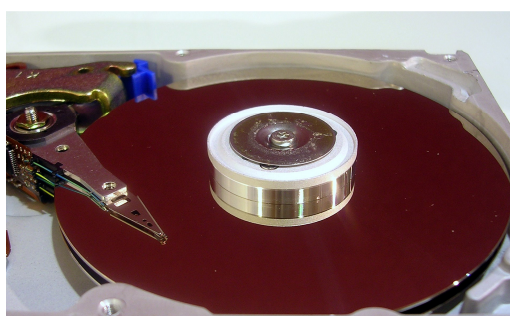


Figure 2 Assembled hard drive

## SIMS and SNMS

Both SIMS and SNMS use a focused, mono-energetic, chemically pure ion beam of typically 1-10 keV to sputter erode the surface under analysis. A small fraction of the sputtered material becomes ionized due to the sputtering process itself and, in SIMS, it is these ions that provide the sensitive information for which the technique is known. Being a mass spectrometry technique all elements and isotopes may be detected, and in favorable conditions the detection limit can be in the low ppb region.

However, because the ionization mechanism for SIMS occurs at the sample surface, it is highly dependent upon the local chemistry and the ionized fraction can vary by many orders of magnitude. This makes SIMS ideal for trace analysis in materials of known matrix but quantification in materials of changing matrix can be complex.

SNMS overcomes the “matrix effect” by separating the sputtering and ionization events. Even in high ion yielding situations the fraction of ions rarely exceeds 1% of the sputtered material, so the neutral flux is much more representative of the sample composition. Ionization for SNMS occurs in an electron bombardment cell at the front of the analyzer which means that the ionization probability is a constant and does not depend upon the sample chemistry.

To quantify SIMS it is important that the reference material be as similar to the unknown as possible and should certainly be of the same matrix material.

For SNMS this matrix matching of

reference materials is unnecessary, as calibration factors do not change with matrix, therefore, the required sensitivity factors can be determined from easily available metal and ceramic samples of published composition.

In addition, SNMS is ideal for the analysis of insulators, as the neutral species are unaffected by sample charging, however, charge compensation is still advisable in order to maintain consistent primary beam conditions.

The ionized secondary particles are analysed and detected in the mass spectrometer. At very low ion beam currents analysis is confined to the top few monolayers – excellent for detection of surface contamination. As the ion beam dose is increased and sputtering becomes more aggressive, subsequently deeper layers are exposed and concentration as function of depth can be determined.

Using a focused ion beam, both SIMS and SNMS become spatially resolving and elemental images can be recorded.

The analysis presented here was made using the Hiden SIMS workstation, a complete and highly flexible quadrupole SIMS/SNMS instrument equipped with the IG20 gas ion gun and MAXIM SIMS/SNMS analyzer.

## Platter Analysis

The disk platter was removed from the drive and a sample area cut from it (approximately 1cm square from the

centre of the data storage area) using a workshop guillotine. No further sample preparation was required and the piece was mounted in a standard holder of the SIMS Workstation.

As nothing was known about the composition of this particular disk surface the first step was to acquire a mass spectrum extending through the entire stack. This is easily accomplished by allowing a stationary ion beam (in this case 600nA 5keV Ar ions focused to 150µm) to sputter erode a pit for a few minutes. As the pit edges provide simultaneous expose of all layers, the mass spectrum gives a good indication of the materials present.

In this case Cr, Ni, and Co showed significant concentrations in the spectrum and these elements were chosen to be followed in the subsequent depth profile together with C (for the surface layer) and Al (for the substrate). In principle, up to 75 individual mass channels may be acquired in a single analysis permitting both matrix and impurity analyses to be made.

The depth profile was measured using 5 keV Ar<sup>+</sup> ions whilst detecting the sputtered neutrals. Secondary ions were rejected by using a high target potential in order to give them energy in excess of that required to pass the parallel plate analyzer of the Hiden Maxim SIMS/SNMS probe.

## Quantification

There are a number of stages to the quantification of an SNMS depth profile. Initially the instrument is calibrated by determining a sensitivity factor for each

element that will be measured, relative to a chosen standard element, for metallurgical samples this is often Fe. It does not matter whether Fe is present in the material under analysis as the relative sensitivity factors (RSFs) will still apply. However, as SNMS is a mass spectrometry technique the specific isotope may be chosen to optimize the analysis and the RSF adjusted for isotopic abundance. The detection limit of SNMS is frequently better than one part per thousand.

The important RSF's for this particular analysis (Ni, Cr, Co) were obtained from sample of Hastelloy C high temperature alloy (NIST SRM C2402 – Hastelloy7C). For simplicity, it was assumed that the substrate is composed entirely of aluminium. However, if necessary the alloy composition of the substrate could also have been determined.

The SNMS depth profile is quantified in a very similar way to those obtained from electron spectroscopies. It is assumed that all elements in the material are monitored and then, after applying the RSFs, this sums to 100% atomic concentration. Additionally, changes in the total signal reflect variation in erosion rate, so, to a first approximation, the SNMS depth profile may be calibrated in both concentration and depth using library values. This is a major advantage over SIMS for the analysis of graded materials and interfaces.

For more precise depth calibration the terminal crater depth is measured using

either interference microscopy or a stylus profilometer. In this particular case interference microscopy was employed.

## Results

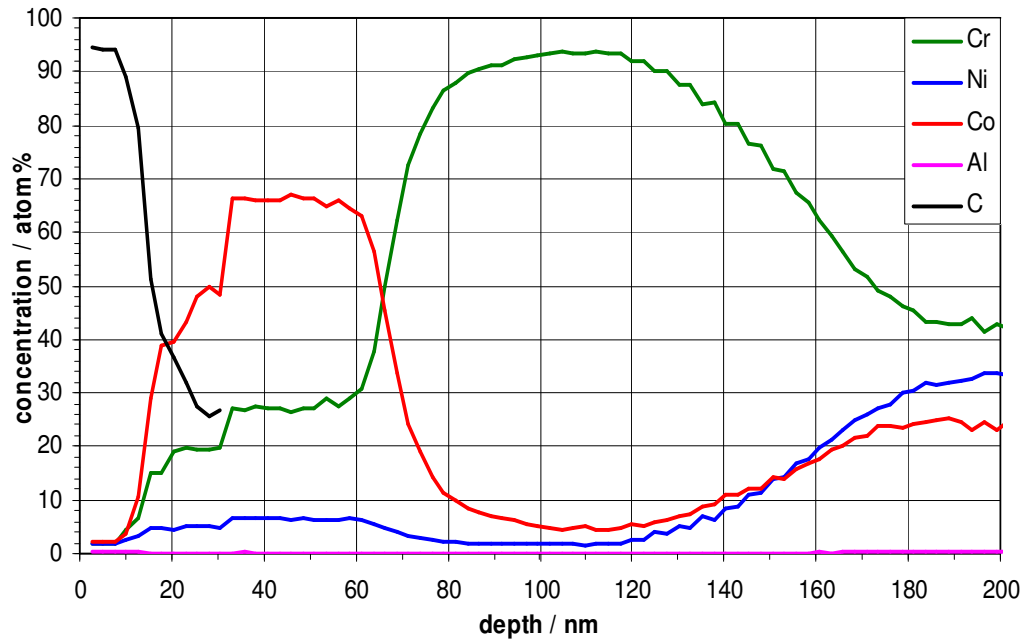
The depth profiles show a structure similar to that expected. At the very surface is a carbon rich layer which acts to protect the magnetic data layer beneath from both the atmosphere and accidental contact by the read/write head.

The magnetic layer is composed of a Co (65%) Ni (7%) Cr(27%) alloy about 40 nm thick. This is separated from the magnetic base layer by a 100nm thick interlayer of 93% Cr. Beneath the interlayer is an 8µm Co (25%) Ni (35%) Cr (40%) thick base layer that serves to complete the magnetic circuit from the head. The above figures are given in atom percent, however, these can be readily be converted to the weight percent figures most frequently given in alloy compositional data.

## Conclusion

Electron impact SNMS on the Hiden SIMS Workstation can provide quantified elemental depth profiles of alloy materials using easily obtained, non-matrix matched, reference materials.

### Near Surface Detail of Hard Disk Platter



### SNMS Depth Profile of Hard Disk Platter

