ABSTRACT FINAL ID: EE-04

TITLE: Probing thermal transport and layering in disk media using scanning thermal microscopy.

AUTHORS (LAST NAME, FIRST NAME): Poon, Siew Wai[1]; Spièce, Jean[2]; Robson, Alexander[2]; Kolosov, Oleg V.[2]; Thompson, Sarah[1]

INSTITUTIONS (ALL): 1. Physics, University of York, York, United Kingdom.
2. Physics, University of Lancaster, Lancaster, United Kingdom.

ABSTRACT BODY:

Digest Body: With the advent of heat-assisted magnetic recording (HAMR) [1] the thermal transport properties of magnetic recording media have become a key performance characteristic. In particular it is important that lateral heat transport is minimised in order to heat only the localised bit area and conversely that vertical heat transport is optimised for fast cooling of the medium essential for the thermal stability of written bits. Magnetic media are multilayered and highly structured on the nanoscale rendering classical treatment of thermal transport inapplicable and the likelihood that the transport is dominated by interfaces and dimensions rather than bulk material properties. A technique for measuring thermal transport on the nanoscale is therefore highly desirable in the design of new magnetic media.

In this study we explore the potential of scanning thermal microscopy (SThM) [2] to resolve thermal transport on the nanoscale and use a multilayered, grain segregated conventional disk with the structure reported in [3]. In SThM the probe in an atomic force microscope is replaced by a thermally sensitive one. The best resolution is obtained using a nanofabricated probe coated, in this case, with a thermally resistive Pd film [4]. The temperature-dependant voltage of the probe is monitored during the experiment and the motion of the probe is controlled by the feedback system of the atomic force microscope allowing simultaneous collection of topographic and temperature data. The tip is excited by an AC current source and heated by Joule heating. As the tip approaches the surface, the temperature of the tip drops due to thermal transport through the sample by radiation, convection and conduction through the sample. All of these transport mechanisms are controlled by the thermal conductivity of the sample and hence the change of temperature of the tip is correlated to the thermal transport properties of the sample. In this study the measurements were taken in ambient conditions which increases the thermal transport, but reduces the spatial resolution compared to measurements in vacuum. The different layers of the sample were accessed by polishing the surface at a shallow angle (typically 12^{o}) with an Argon ion beam to generate cross-section samples. This was done using the beam-exit cross-sectional polishing (BEXP) technique at Lancaster [5,6]. In this setup the argon ion beams impinge on the side of the sample at a small angle and exit the surface at a small angle, producing a cut with sub-nm roughness through the area of interest. The particular geometry of a BEXP cut ‘stretches’ layers over a larger area when compared to a traditional cross-section and allows the sample surface and cross-section to be studied at the same time. The sample can then be scanned across the layers as shown in Figure 1.

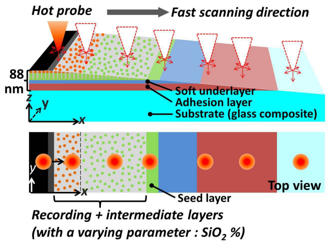
The active recording layer was a sputtered CoCrPt alloy segregated in a matrix of silica to decouple the grains. Three samples were studied with different silica concentrations while maintaining the same underlayer structures to study the influence of silica in lateral transport. The median grain diameter was 6.7nm but is a weak function of the silica concentration [3]. The multilayer stack was as follows: glass substrate / adhesion layer / Fe-based soft underlayer / Ru /Ta seed layer / intermediate layer / CoCrPt-SiO_2 recording layer / diamond-like carbon and lubricant surface layer can also be seen in Figure 1.

Figure 2 shows the topography and thermal images of the cross-section of the sample with the lowest oxide concentration and multiple line scans across the image. The first point to note is that the thermal image greatly enhances the topographic information. For example, topographic changes create additional thermal transport paths between tip and sample and serve to amplify the topographic information. Here, the gradient changes at interfaces are enhanced. Hence the layers which range in thickness from 2 to 30nm are clearly resolved in the thermal image, but not in the topographic image. Figure 1 shows the complexity of the transport path through the sample along the path of the line scan, demonstrating the need for modelling to provide quantitative analysis. Comparing the results for the three samples indicates that the silica content affects the thermal transport, giving an insight into the thermal transport of the recording medium. Further modelling is required to directly attribute these differences to particular features of the media.

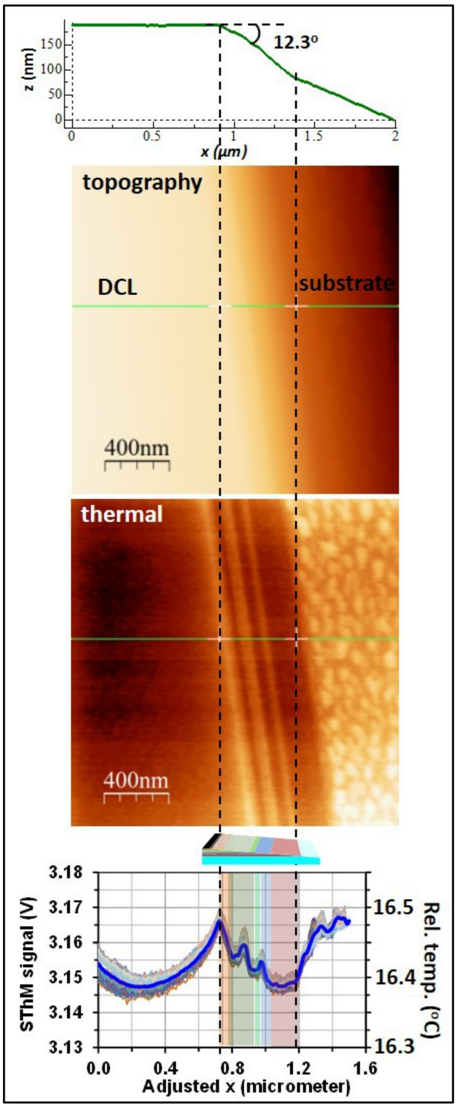
Acknowledgement

The CoCrPt media was provided by Professor Kevin O’Grady, University of York

References: [1] M. H. Kryder et al., Proc. IEEE 96, 1810 (2008).
[2] S. Gomès et al., Phys. Stat. Solid. (a) 212, 477 (2015) and references therein.
[3] J. Chureemart et al., J. Appl. Phys. 114, 083907 (2013)
[4] Yuan Zhang et al., J. Vac. Sci. Technol. B30, 010601 (2012)
[5] O.V. Kolosov et al., Nanotechnology, Vol. 22, No. 18, 185702, (2011)
[6] O. V. Kolosov & I. Grishin, Patent No. WO/2011/101613 (2011)



Cartoon to show the principle of cross-sectioning the sample, the details of the layered structure and the direction of scanning. The surface layer (diamond-like carbon DLC) is on the far left and the substrate (glass composite) is on the far right.



Topography and thermal images of the sample with the lowest oxide concentration. Also shown are the gradient of the sample after polishing and multiple line scans across the thermal image. The thick line is the average of the line scans which is used for fitting the data.

IMAGE CAPTION:

Cartoon to show the principle of cross-sectioning the sample, the details of the layered structure and the direction of scanning. The surface layer (diamond-like carbon DLC) is on the far left and the substrate (glass composite) is on the far right.

Topography and thermal images of the sample with the lowest oxide concentration. Also shown are the gradient of the sample after polishing and multiple line scans across the thermal image. The thick line is the average of the line scans which is used for fitting the data.

TABLE TITLE: (No Tables)

(No Table Selected)

CONTACT (NAME ONLY): Sarah Thompson

CONTACT (EMAIL ONLY): sarah.thompson@york.ac.uk