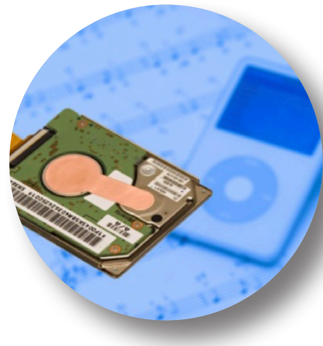
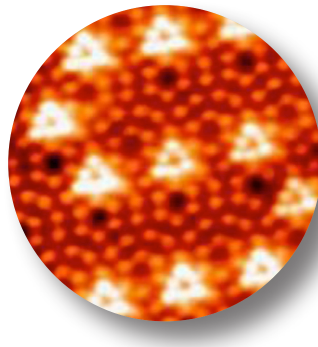
Case Study

# Understanding dilute chemistry and magnetism



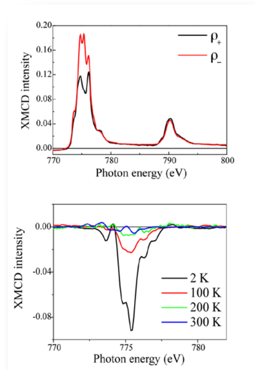
## The Problem

The rapid progress in micro-miniaturisation of information storage has reached a stage where quantum mechanical effects become a limiting factor. The new field of spin transport electronics or 'spintronics' exploits both the spin and charge of electrons to combine the characteristics of magnetic and semiconductor devices to develop a new generation of smaller, more energy efficient storage systems.



## The Challenge

Dilute magnetic oxides (DMO), formed when dilute levels (ca. 5.4 atomic %) of magnetic impurity transition-metal ions are randomly substituted into a host oxide lattice, are one of the most puzzling and interesting classes of magnetic materials that have emerged in recent years. These materials may exhibit ferromagnetism above room temperature suitable for next generation spintronics-based multifunctional devices. Despite the wide application in magnetic materials the origins of the magnetic response is still not completely understood.




## The Solution

Researchers from the University of Cambridge teamed up with scientists on Diamond's I06 Nanoscience beamline to investigate the origins of magnetism in Co-doped Indium Tin Oxide (ITO) thin films using X-ray Absorption Spectroscopy (XAS) combined with X-ray Magnetic Circular Dichroism (XMCD) at the In, Sn and Co absorption edges over a range of temperatures. The XAS spectra were recorded in both Total-Electron Yield (TEY) and Fluorescence Yield (FY) modes in order to probe the structure of surface and bulk components.

## The Benefits

The XAS study indicated that the Co ions were in a pure $Co^{2+}$ state. This study showed that the ferromagnetism observed in Co-doped ITO is not related to the Co 3d electronic states. These findings indicate that the bulk ferromagnetism may be oxygen mediated, e.g. oxygen vacancies or oxygen-induced defects. Future studies will be directed toward detailed measurements at the O K-edge in order to identify whether the observed results could be signatures of oxygen related lattice defects.

*"Using the instruments and expertise at Beamline I06 at Diamond gave us the opportunity to obtain site-specific information on the nature and potential origins of room temperature ferromagnetism in our dilute magnetic oxide. The results of this extensive study have increased our understanding of magnetism in the materials, paving the way for integration within future spintronic devices."*

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