IMAGING MAGNETIZATION IN $Ga_{1-X}Mn_XAs$

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Introduction

Since its discovery by Ohno et al.,[1] Mn doped GaAs has received considerable attention. In part, this is due to the exciting magneto-optical applications that may be enabled by magnetic semiconductors, such as materials capable of emitting and detecting circularly polarized light. Apart from its use in potential applications, $Ga_{1-x}Mn_xAs$ also presents a unique opportunity to study carrier-mediated magnetism in a well-controlled environment. It is also believed this prototypical semiconductor may hold the key to incorporating magnetic memory devices in conventional electronics. However despite its great technological promise, the possibility of manipulating the magnetic state of $Ga_{1-x}Mn_xAs$ via standard electronics has remained largely unexplored.

Experimental

Using standard photolithographic techniques we have fabricated a gold loop capable of producing large (approximately 0.03 Tesla) magnetic fields on the surface of an annealed $Ga_{0.0927}Mn_{0.073}As$ film. We have then used the Kerr microscopy setup at the NHMFL to image changes in the magnetic state of the film upon application of electronically generated magnetic field. This was accomplished with a continuous wave titanium-sapphire ring laser with a balanced detection scheme.

Results and Discussion

A representative Kerr image taken at 10 Kelvin is displayed in Figure 1. The image covers an area on the sample of 60 μm x 60 μm with a resolution of 0.5 μm. The image clearly shows a change in the magnetization of the sample can be achieved using standard electronic techniques. However the image also contains notable features that can extend over significant distances (notice the large blue jet that emerges on the top). Nonetheless these changes were achieved using standard photolithographic techniques and modest applied voltages (4.0 V).

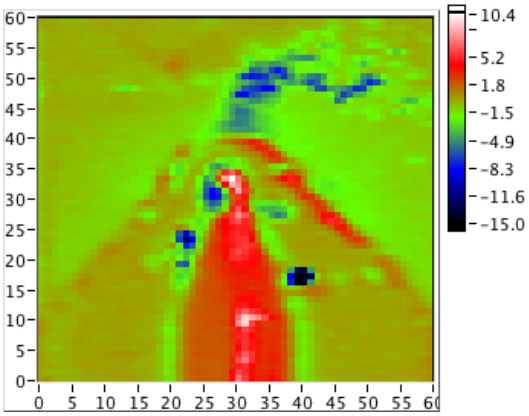

Figure 1: Representative Kerr image for an annealed $Ga_{0.927}Mn_{0.073}As$. Color indicates a change in the Kerr rotation that should be proportional to the magnetization normal to the sample surface.

Conclusions

We have presented measurements that demonstrate a change in the magnetization of GaMnAs loop in a non-perturbitive manner using standard electronics and a photo-lithographically defined current. The preliminary results presented here indicate that it will be difficult to produce small scale changes in the magnetization of the materials. Nonetheless these exciting results clearly demonstrate the promise of diluted magnetic semiconductors in future magneto-electronic storage devices.

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References

[1] H. Ohno, Science **281**, 951 (1998); H. Ohno, *et al.*, Appl. Phys. Lett. **69**, 363 (1996).