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Control of Magnetic Properties in Metallo-Organic Thin Films

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Abstract – Magnetic metallo-organic thin films have been prepared at different growth temperatures to characterize the influence of structural properties on the magnetic characteristics. A quantitative analysis of the grain size shows that the growth temperature increases the elliptical grain size considerably (Fig. 1). Long grains of planar iron phthalocyanine form quasi one-dimensional iron chains, which are embedded in a carbon matrix along the other two dimensions. Magnetic properties, such as saturation magnetization depend on the structural details (Fig. 2). Therefore, it is feasible to tune magnetic properties using deposition parameters that influence the film morphology.

Metallo-organic thin films of iron phthalocyanine (FePc) were deposited onto sapphire substrates.[1,2] The control of the substrate temperature in the range of 25°C to 260°C allows for strong surface modifications as shown in the atomic force microscopy images in Fig. 1. The increased surface temperature during the deposition promotes surface diffusion and improves the self-assembly process of molecules on the substrate.[3] A quantitative structural study of over 3000 grains per sample shows that not only the grain size is asymmetric, but the distributions of the minor and major axes of these elliptically shaped grains differ significantly. Ellipses that are fit to grains have the minor axis distributed normally, while the major axis follows a lognormal distribution. This distribution imbalance is due to the planar shape of the molecule.

The strongly elongated grains form the basis of quasi one-dimensional iron chains. Chains are separated by a carbon matrix with typical inter-chain distances of 1.3nm and much closer intra-chain distances of 0.3nm. The control and variation of the average chain length is used to study the magnetic properties of these quasi one-dimensional magnetic chains. Iron phthalocyanine shows hysteretic magnetization behavior below 5K (Fig. 2) that is obtained from vibrating sample magnetometry. Two characteristic pockets and coercitives near 300 Oe are observed. The volume saturation magnetization increases for samples with larger grains. A correlation between the average grain size, or average chain length and the magnetization signal strength is observed. Qualitatively, the longer chains produce long-range magnetic interactions that raise the volume magnetization. This approach of forming magnetic chains is an excellent tool to vary magnetic properties that are fixed in the bulk form.

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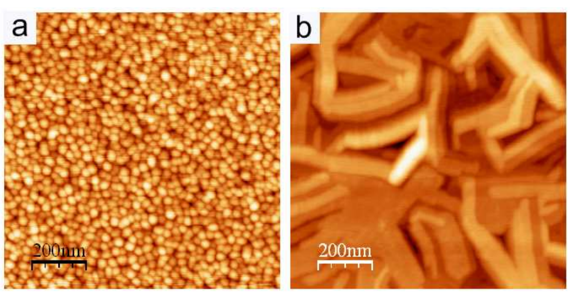

Figure 1: *Atomic force microscopy images of 20 monolayer thick iron phthalocyanine films deposited at (a) 25 °C and (b) 260 °C. Both images are 1 x 1 μm in size. The average grain size increases from 35 nm in length to 200 nm in length.*

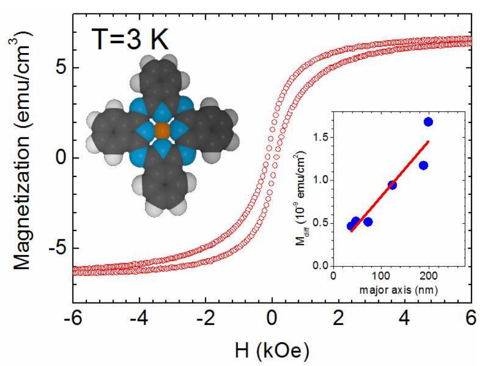

Figure 2: *The hysteresis loop of iron phthalocyanine thin films at 3K shows the ferromagnetic behavior. The left inset is a rendering of the iron phthalocyanine molecule. The right inset shows the correlation between the magnetization signal strength and the average major axis length.*

References

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