Magnetic interaction in assemblies of nanometre-sized Fe dots on Cu (111)

Maria A.Torija[1,2], John P. Pierce[1,2], E. Ward Plummer[1,2] Jian Shen[1]
1 Oak Ridge National Laboratory,TN USA
2 University of Tennessee, Knoxville, TN, USA

mtorija@utk.edu

Short Abstract
We observed ferromagnetic stability of an assembly of iron nanodots on Cu (111) prepared by buffer layer assisted growth. By varying the spacing between the dots , we identified dot-dot interaction(s) to be the key for the ferromagnetic behaviour.

Keyword
Fe, Nanodots

Introduction

Nanoscale isolated magnetic particles are superparamagnetic in nature. For an assemble of nanodots, the overall magnetic behaviour, however, is a result of the interplay between magnetic anisotropy and magnetic interactions including dipolar interaction and indirect exchange interaction via the substrate.
Because the magnetic interactions are most sensitive to the change of spacing between nanodots, experimentally we can identify the role of the interactions by measuring the magnetic behaviour as a function of the dot-dot spacing. In our work, we will further strengthen this approach by fixing the size distribution while varying the dot-dot spacing.

Experimental details

Assemblies of separated iron quantum dots have been prepared on Cu (111) via buffer layer-assisted growth process in an ultra high vacuum system. Firstly, an inert Xe layer is frozen onto a Cu (111) substrate that is well bellow 30 K. After that, Fe is dosed using a thermal evaporation source and form clusters on the Xe layer. Finally the sample is warmed above 90 K to evaporate the buffer layer allowing the Fe clusters to land on the Cu surface. A set of different samples with varying size but the same nominal thickness has been analysed. In addition, we have compared magnetic behaviour of the samples with the same size distribution but different density.

Results and discussion

As measured by statistics of STM images in fig.1-4, we can control the size and the density of the Fe dots by varying either the Xe buffer layer thickness and/or the Fe dosage. The Fe dot assemblies show non-zero remanent magnetization that is stable with the passage of time in all cases. To distinguish the roles of the magnetic interactions vs. the magnetic anisotropy in stabling the remanent magnetization, we compare the ordering temperature of dot assemblies that have equal size distribution but different density. At a fixed dot size distribution, varying the density of the Fe dots from 0.003 to 0.015 dots/nm^2 leads to an enhancement of ordering temperature from 153 K to 363 K. This clearly indicates that magnetic interactions play an important role in stabling the remanent magnetization.
Another interesting phenomenon that we observed is a spin reorientation induced by the dot size. Fig 6 shows that for a fixed nominal thickness, the easy axis of magnetization is perpendicular for lower Xe thickness (small dots), and becomes in-plane for higher Xe thickness (big dots)

Conclusions

Our results indicate that magnetic interaction between the dots plays an important role in stabilizing the remanent magnetization. The dot size-induced spin reorientation may be explained by the interplay between surface and bulk anisotropies.

Acknowledgements
Research supported by ORNL, managed by UT Battelle,LLC for the U.S. D.O.E under Contract DE-AC05-00OR22725 and the U.S. National Science Foundation under Contract DMR-0105232

Figures

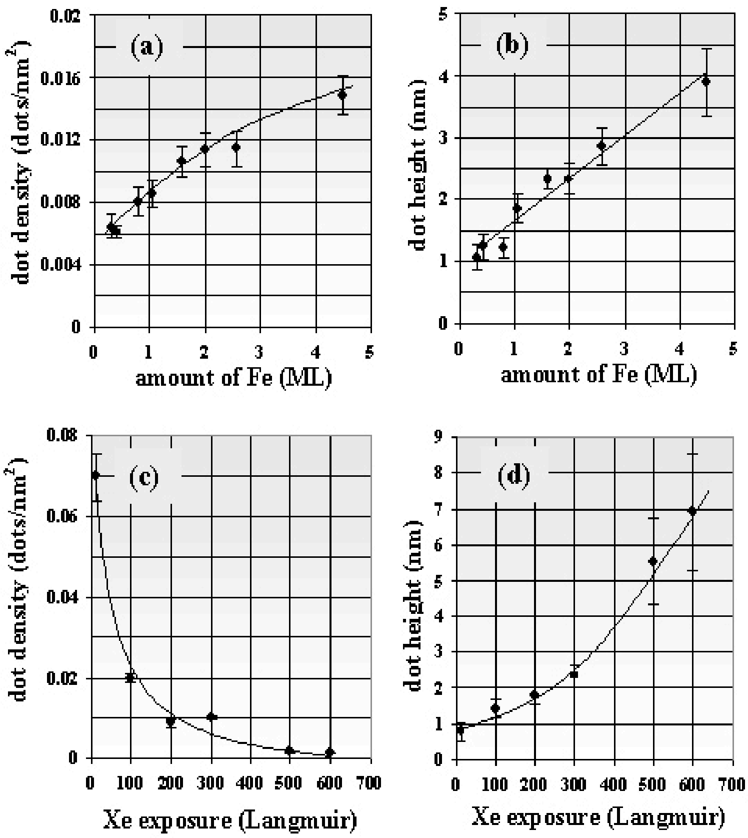

Figure1-4

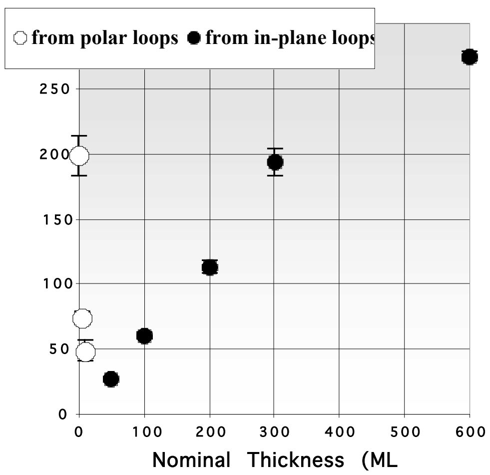

Figure 5