

Nanostructuring iron on the Cu(111) surface: Spatial confinement and magnetism

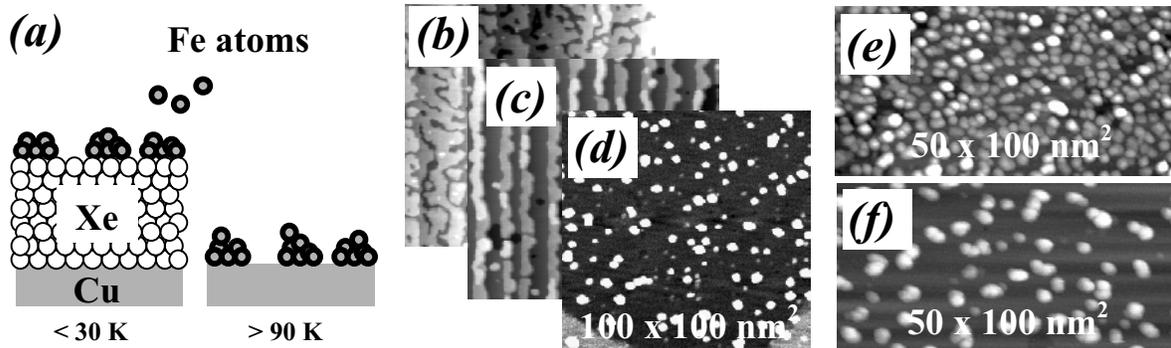
John P. Pierce^{1,2,*} and *Jian Shen*¹

¹Oak Ridge National Laboratory, ²The University of Tennessee

*competing for the Nottingham Prize - thesis advisor: Ward Plummer^{1,2}

One major challenge in understanding magnetism in nanostructures is overcoming template effects. The root of this problem is that it is often the case that only one type of structure, whether it is a rough film, smooth film, nanowire array, or cluster assembly, is energetically favored to grow on a particular substrate. To produce different nanostructures from a given material, people have therefore had to reach for different templates. Since the electronic, structural, and magnetic properties of atomic-scale entities are profoundly impacted by the substrates that support them, comparisons between entities grown on different templates don't reveal the intrinsic differences induced by nanostructuring. A second challenge in this field is learning to make systematic changes in the size and spacing of various nanostructures in order to investigate the roles that confinement and inter-particle interactions play in determining their behavior.

These challenges have been met for the case of Fe on the Cu(111) surface. Assemblies of separated iron clusters can be prepared on Cu(111) via a buffer-layer-assisted growth process. [See Fig. (a) below.] These studies can be combined with previous work to show how the magnetic properties of 0.8 atomic layers of Fe change as it is prepared as an atomically flat film [Fig. (b)], nanostripe array [Fig. (c)], and cluster assembly [Fig. (d)]. Surface magneto-optic Kerr effect (SMOKE) studies show that changes in the anisotropy, the field-, temperature-, and time-dependence of the magnetization, and moment per atom are not as simple as predicted by simple models of low-dimensional magnetism.



Our STM work reveals that we can control the average spacing and size of the dots by changing the Xe layer thickness and/or the amount of Fe deposited. [Figs. (e) and (f) correspond to dots made with one monolayer of Fe and respective Xe doses of 10 and 100 L.] Using the SMOKE, we find that the magnetic ordering depends quite strongly on both the dot separation and size. This, along with the fact that the dot assemblies show non-zero remanent magnetization that is stable with the passage of time, indicates that *dot-dot interactions* are quite significant in this system. Monte Carlo simulations can reveal to what extent these interactions are dipolar or substrate-mediated in origin. The anisotropy of the system evolves in an interesting way as the Xe buffer layer is thinned. For dot assemblies prepared with thick (over 50 L exposure) Xe layers, we see a decrease in the temperature at which in-plane remanence exists as the Xe dose is reduced. Below a critical Xe exposure, the easy axis of magnetization of the system is perpendicular to the surface plane and reducing the Xe exposure increases the temperature at which perpendicular remanence exists.