2003 MRS Spring Meeting, Symposium P: Self-Assembled Nanostructured Materials

Poster

NUCLEATION AND SELF-ASSEMBLY OF ULTRATHIN IRON OXIDE FILMS ON A RU(0001) SUBSTRATE

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Heteroepitaxial growth of ultrathin iron oxide films and iron oxide nanostructures on a Ru(0001) substrate is investigated by scanning tunneling microscopy (STM) and low-energy electron diffraction (LEED). Metastable FeO(111) layers grow with a thickness up to 4 monolayers (ML) on Ru(0001) by oxidation of the corresponding amount of Fe in 10^{-6} mbar O_2 at 870 K with a final anneal to 1000 K. These films have strongly expanded lattice constants and form specific coincidence structures with the Ru(0001) substrate. Prolonged oxidation transforms the whole film to the thermodynamically more stable Fe_3O_4(111) phase. This phase transition requires at least two bulk repeat units of Fe_3O_4(111) and does therefore not occur in very thin FeO(111) films. Oxidation of 1-3 ML thick FeO(111) films leads to a heterogenous nucleation of Fe_3O_4(111) islands, preferentially at step edges. Homogenous nucleation of self-assembled, periodic Fe_3O_4 (111) nanodomains with diameters of ~2-3nm embedded in an ultrathin FeO(111) occurs in ~4 ML thick FeO(111) films. The driving force is the an electrostatic energy gain and an energy gain associated with the exothermic phase transition to Fe_3O_4. These nanostructures represent a promising candidate for the realization of quantum magnetic disks. Further oxidation causes these domains to grow and finally coalesce into a closed Fe_3O_4 (111) film. The growth and phase transitions of iron oxide film structures are compared to the previously investigated Stranski-Krastanov growth of iron oxide films on Pt(111) [W. Weiss, M. Ritter, Phys. Rev. B59 (1999), 5201]. Differences in the growth behaviour of iron oxides on different substrates are discussed in terms of the different affinity of the iron oxide film towards the substrate material showing that the stabilization mechanism and growth mode for the same metal oxide phases depends strongly on the interfacial interaction.

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