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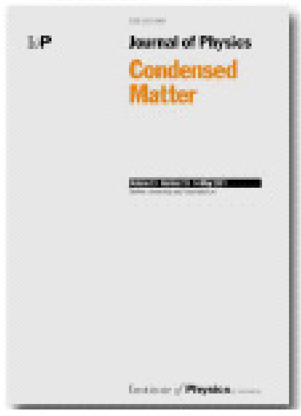

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Magnetism of films, stripes and dots

The effect of spatial confinement on magnetism: films, stripes and dots of Fe on Cu(111)

J Shen et al.

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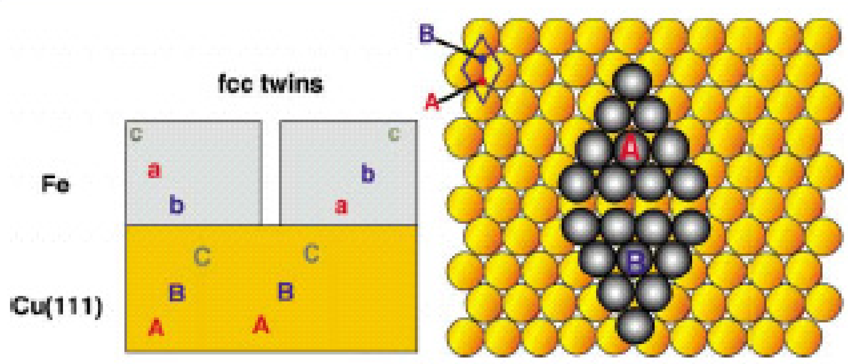

Schematics showing the phenomenon of twinning. The spacing between iron atoms on the Cu(111) surface is such that iron atoms in a particular island will either occupy 'A' sites only or 'B' sites only, depending on which of these two sites was settled upon by the atom that seeded the island. The image shows the fault line that forms when an A-type island tries to merge with a B-type island.

Magnetic nanostructures are important both for their basic physics and device applications. New properties that emerge at the nanoscale have at least four origins:

(1) Surface and interface effects dominate as the surface-to-volume ratio increases.

(2) New quantum phenomena such as oscillatory exchange coupling, GMR, spin-dependent tunnelling and exchange bias manifest in magnetic multilayers.

(3) Effects when the system dimensions are comparable with 'characteristic lengths' such as the spin-diffusion length — the exotic effects seen in GMR spin valves, for example.

(4) In many spin systems, like CMR materials and magnetic semiconductors, correlation effects spin fluctuations and spin transport, already important in the bulk spin structure, are enhanced by spatial confinement.

E W Plummer's group at Oak Ridge and J Kirschner at MPI for Microstructure physics, Halle review the successful growth of ultrathin films, nanowires and nanodots of Fe on Cu(111) using self-assembly principles, even though they cannot be grown by conventional techniques. The fact that these three types of nanostructures can be grown on a common template allows direct observation of the effects when the Fe nanostructures are smaller than the magnetic domain size in one, two and three dimensions. This particular system, Fe on Cu(111), has shown that the magnetic properties of a system do not change monotonically and predictably as the dimensionality of the system is reduced. Unresolved issues include the microscopic origin of the low-moment phase and the anomalous thickness dependence of the Curie temperature in laser MBE-grown films, and the surprising difference in the magnetic stability of the nanowire and quantum systems.

Future work on magnetic nanostructures prepared on insulating substrates, where there would be true confinement of the electrons, could be of particular importance. These systems might show, for instance, how electron spin can influence electronic transport in a magnetic nanowire. However, a considerable amount of work remains in developing techniques for the controlled synthesis of such systems.