Pinning Effects by Arrays of Magnetic Dots on Superconductors

Ivan K. Schuller, Y. J. Rosen, A. Sharoni
Physics Department, University of California, San Diego
La Jolla, Ca. 92093, USA

D. Perez de Lara, E. M. Gonzalez, J. L. Vicent
Departamento de Fisica de Materiales, Universidad Complutense
28040, Madrid, Spain

J. E. Villegas
Unite Mixte de Physique CNRS/Thales and Universite de Paris Sud 11,
91405 Orsay, France

Electron beam lithography is a powerful technique which allows the preparation and control of arrays of small magnetic dots. In this way, we have fabricated, triangular and square lattices, lines etc. of submicrometer magnetic dots (Ni, Co and Fe). We have studied the magnetic and transport properties of these arrays using a variety of techniques including magnetotransport, magnetization, Magnetic Force Microscopy and light scattering.

The interaction between an ordered array of small magnetic particles and a superconducting thin film can lead to important pinning effects due to the synchronized interaction with the vortex lattice. The resistivity vs. magnetic field curves present sharp minima close to the transition temperature, whereas the transport critical currents exhibit pronounced maxima. These minima and maxima appear at constant field intervals, clearly related with the lattice parameter of the artificial pinning array. The angular dependence reveals that this interval increases with the angle between the field and the film normal showing that only the perpendicular component of the magnetic field is relevant for this synchronized pinning effect. I will describe a series of experiments and comparisons to address many of the aspects of this interesting collective matching phenomenon including ratchet effects, bistable superconductivity, vortex channeling and fractal behavior.

Work supported by the US-NSF and the Spanish Ministerio de Ciencia e Innovacion.