Combining opposing properties for synergistic function

June 27 2012

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The properties of nanomaterials often differ in novel ways from those of the bulk material of the same substances. European researchers investigated a completely new class of such materials that could be important for magnetic memory devices.

The field of nanomaterials (on the size of atoms and molecules) is growing at a rapid rate. Development of novel devices depends on development of novel materials capable of large-scale synthesis and manufacturing in order to exploit commercial potential.

EU-funding of the 'Superconductivity - ferromagnetism interplay in nanostructured hybrid systems' (SFINX) project enabled European researchers to investigate a novel class of hybrid nanomaterials

combining superconducting (S) and ferromagnetic (F) metal components.

Ferromagnets are substances that become magnetised in the presence of a magnetic field. Superconductors are materials that, when cooled to close to absolute zero, lose virtually all electrical resistance (resistance to current flow). Resistance is the electrical opposite of conductance. Along the way, the materials become diamagnetic, or not attracted to a magnetic field due to a lack of unpaired electrons.

Thus, S-F hybrid structures represent an antithesis of properties. Occurring naturally in only very few materials, artificial synthesis of such structures could produce as yet undefined quantum ground states and kinetic properties. Such characteristics could have impact on next-generation magnetic memory devices.

Researchers developed methods to grow and control barriers between F and normal metal (N) (F-N) and two ferromagnetic (F-F) metals. They created S films with embedded magnetic nanoclusters, studying the co-existence of S and F components in S films. Furthermore, the scientists developed theoretical descriptions of the magnetic field dependence of resistivity of F materials on the magnetisation of magnetic clusters.

A theoretical framework for describing spin dependence of properties of F-S-F structures and S-F-S structures was put together. Spin has to do with the angular momentum of elementary particles in motion through these devices. Researchers also manufactured some hybrid microcircuits to study the effects experimentally.

The SFINX consortium made significant progress in theoretical description of novel S-F hybrid nanostructures that exhibit new properties. These are based on both the nanoscale of the materials as well as on the somewhat opposite inherent properties of the individual

components related to electronic and magnetic effects. Future magnetic storage devices may thus have enhanced functionalities based on the combination of specific properties of F and S materials.

Provided by CORDIS