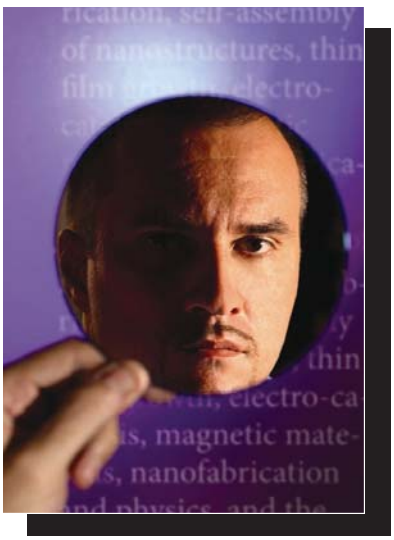
MAGNETICS
BUSINESS & TECHNOLOGY
www.MagneticsMagazine.com a webcom publication SUMMER 2007

Nanoengineering Research at UH a Magnet for Defense Department Grant

Quest to Build Most Powerful Magnetic Field Sensor Could Reap Military, Medical Benefits

Whether you're a soldier navigating a minefield or a doctor examining a tumor, how well you know the territory can make all the difference in the outcome. That's why military and medical personnel increasingly rely on magnetic field sensors to help map their respective terrains and why the US Department of Defense (DOD) has awarded a University of Houston researcher and his team a grant worth up to $1.6 million to build the most powerful magnetic field sensor to date.



Stanko Brankovic, an assistant professor of electrical and computer engineering with the Cullen College of Engineering at UH and co-principle investigator Paul Ruchhoeft, also a UH assistant professor of electrical and computer engineering, will use the grant to create a new type of magnetic field sensor that, if successful, will be hundreds - perhaps thousands - of times more sensitive than anything currently available.

On the military front, hundreds of thousands or more of these sensors could be the key components in a low-cost system that maps minefields quickly and accurately. In the medical arena, the sensors could be applied to magnetic resonance imaging, yielding highly detailed images of, for example, a tumor or an injured knee.

The funding for the project, "Single Ferromagnetic Nanocontact-Based Devices as Magnetic Field Sensors," will be delivered in two stages. The first stage, valued at $100,000 for one year, requires a proof of concept, in which Brankovic and Ruchhoeft must construct a working sensor. To do this, they will utilize new ideas in the nanoengineering of novel materials and the development of nanofabrication processes for devices smaller than 10 nanometers.

Should they succeed, the DOD will consider awarding them an extra $1.5 million to complete an entire system that incorporates multiple sensors, data-transmission equipment and equipment and software that translate data into an easily understandable format.

The team's sensors will be based upon the phenomenon known as "ballistic magnetoresistance," which is the effect of a magnetic field on the ability of electrons to flow between magnetic electrodes through a nanocontact - a tiny wire measuring billionths of a meter that forms naturally between magnetic electrodes.

If the two electrodes' magnetic orientations (the direction in which a material's magnetism pushes or pulls) are different, some of the electrons flowing between them will be repelled by the spot in the nanocontact where the two different magnetizations meet, Brankovic said.

"When exposed to a magnetic field, however, the resulting change in magnetic orientation of the electrodes affects electrons' ability to travel through the nanocontact," he said. "Depending on the size and material of the nanocontact and magnetization of the electrodes, the electrons will flow through either more or less easily."

This change can be measured by simple tools such as a voltmeter. On the bulk scale, magnetoresistance - the change in electrical resistance of a conductor when a magnetic field is applied - is only one factor in determining how easily electrons travel between electrodes. On the nanoscale, in which these magnetic field sensors will be constructed, magnetoresistance is the only cause of fluctuation in the flow of electrons.

The heart of Brankovic's system will consist of two magnetic electrodes, connected by a very small magnetic nanocontact.

When exposed to a magnetic field, the flow of electrons through the nanocontact will change, yielding a measurable result.

Exactly how magnetoresistance works on this scale is unknown and will be one of the subjects of Brankovic's research. Two of the main theories to explain the phenomenon - both of which are supported by limited physical evidence - are incompatible. Brankovic has developed his own hypothesis that, if correct, would account for both sets of evidence.

"In my hypothesis, the nanocontact connecting the two electrodes is composed of non-conductive metal oxide that has metal channels that act as conductive pathways for electrons," Brankovic said. "When exposed to a magnetic field, some, but not all, of the channels of conductive material are altered either by the magnetic domain wall or by magnetostriction - the phenomena of a material's shape changing slightly when exposed to a magnetic field. Either of these explanations would result in a small but measurable change in the flow of electrons."

Whether this supposition proves correct or magnetic resistance on the nanoscale works in some other manner, Brankovic's goal will remain the same: to build a first-of-its kind magnetic field sensor that is far more powerful than any other sensor to date. If he succeeds, his invention will create a fundamental change in the arena of magnetic field detection.