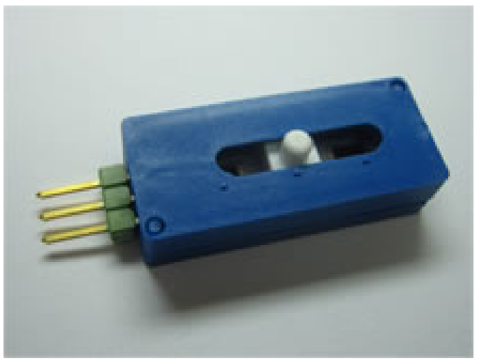
Position sensors: magnets know their place

February 25 2008



Non-contact position sensors are small but important parts of many modern machines. Researchers have used a phenomenon known as magnetoresistance to develop a practical, low-cost position sensor that performs better than existing designs. Commercial production will follow this year.

Electronic sensors that record the position of movable objects crop up in practically every machine, from printing presses to space rockets. The average modern car has more than 60 sensors to measure the positions of the crankshaft, throttle, clutch, suspension and dozens of other moving parts. These sensors need to be cheap (€0.5-5), yet very robust and reliable.

The oldest kinds of position sensor are mechanical switches and sliding resistors (potentiometers). Because they depend on direct electric contact, they are vulnerable to wear, corrosion and breakage, so modern designers tend to avoid them.

Instead, non-contact sensors based on magnetic phenomena are popular. In a non-contact sensor, a coil of wire (inductive and galvanometric sensors) or a semiconductor element ('Hall effect' sensor) detects the presence of a magnet mounted on another part of the machine.

But traditional magnetic sensors tend to be both insensitive and fairly expensive. And 'Hall effect' sensors have the additional disadvantage of being 'on/off' devices that cannot track the exact position of an object.

Introducing magnetoresistance

Partners in the MUNDIS project thought they could do better. And their results show they were right, with a market-ready product soon to follow. The EU-funded project developed more sensitive and cheaper position sensors based on magnetoresistance. This phenomenon, which describes how a magnetic field changes the electrical resistance of certain materials, has been known since the nineteenth century, but until recently had no industrial applications.

'Giant magnetoresistance' (GMR) was discovered in 1988 and now finds application in computer hard disks. Both GMR and another effect known as thin-film magnetoresistance (TMR) could be used for position sensors. According to MUNDIS coordinator Professor Ricardo Ibarra, however, GMR and TMR are the province of large companies, because they require huge investment in cleanrooms and other equipment developed for the semiconductor industry.

More promising for the EU-funded MUNDIS, Ibarra says, was an effect known as ballistic magnetoresistance (BMR). Electrons have a property called spin (magnetic moment) that allows them to be influenced by a magnetic field as they fly between nanoparticles (hence “ballistic”). When a current passes through nanoparticles of iron oxide deposited on a plastic film, electrons are susceptible to BMR as they travel across nanocontacts between the nanoparticles.

The MUNDIS partners experimented with two different ways of making nanoparticles. The first route, which involves grinding iron oxide with a ball mill, yielded practical sensors that are both sensitive and reasonably cheap. The second method uses electrochemistry to deposit nanoparticles directly from solution.

“We have not finished developing the electrodeposition technique, but it is very promising,” says Ibarra. “It can create devices that are even more sensitive, and they should eventually be cheaper, too.”

Vertical focus

From the start, MUNDIS aimed to create a practical BMR device: a gear stick position sensor for the automotive industry. This is a four-position ‘on/off’ sensor with a target cost of €5, falling to €4 with bulk production.

By January 2008, three months before it was due to finish, the project had shown excellent results. The partners had developed all the parts needed for a complete gear stick position sensor: the film-based sensor itself, the associated printed circuit board, and a magnet carrier. Tests showed that the device can operate reliably for 10 million cycles, as well as withstanding vibration, humidity and thermal stress.

The technology is patented and licensed to two Spanish SMEs who were partners in the project. Aragonesa de Componentes Pasivos (ACP), a manufacturer of electronic components including position sensors, makes the sensor material. Ficosa International, which makes automotive components and systems, then assembles the complete sensor. The cost is even lower than the original target, and the new sensors will be on the market within a few months, Ibarra says.

Tasks remaining to be done include improving control of the initial resistance of the sensor material, and gaining a better understanding of what happens within the nanostructure.

“Although the sensors work well, it may be that not all of the magnetoresistive effect in fact comes from BMR,” says Ibarra. To study the mechanism of BMR in detail, the researchers are now using a focused ion beam to build tiny circuits, less than 1 μm in size, involving just a few nanoparticles.

The sensors can be made in almost any shape, Ibarra says, and in principle there is no lower limit to their size. Since smaller sensors are expected to work better than large ones, some innovative applications might emerge.

One exciting potential application is in biosensing. “If we could get a magnetic nanoparticle to stick to a microorganism, then we could use a BMR sensor to detect the magnetic particle and hence the organism,” Ibarra suggests. This is clearly a technology with potential.

Source: ICT Results

Citation: Position sensors: magnets know their place (2008, February 25) retrieved 10 April 2024 from https://phys.org/news/2008-02-position-sensors-magnets.html