Graphene breakthrough as Bosch creates magnetic sensor 100 times more sensitive than silicon equivalent

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Graphene Week 2015 is awash with outstanding research results, but one presentation has created quite a stir at this Graphene Flagship conference. To a stunned audience, Robert Roelver of Stuttgart-based engineering firm Bosch reported on Thursday that company researchers, together with scientists at the Max-Planck Institute for Solid State Research, have created a graphene-based magnetic sensor 100 times more sensitive than an equivalent device based on silicon.

Bosch has long been involved in sensor technology, notably in the automotive sector. In 2008, the company expanded beyond its pressure, acceleration and gyroscopic motion sensors, to geomagnetic, temperature, humidity, air quality and sound pressure devices, including for use in consumer electronics devices such as mobile phones. Roelver noted that Bosch is the world's number one supplier of microelectromechanical sensors, with €1bn in sales.

Interested in whether graphene could enable new applications and improved sensor performance, Bosch has been investigating the use of the two-dimensional material in its pressure, magnetic, humidity, gas and sound pressure devices. The first step was to look at fabrication methods.

Top-down approaches to graphene device fabrication such as mechanical and chemical exfoliation would not work on a commercial scale, so

Bosch focussed instead on bottom-up techniques such as the thermal decomposition of silicon carbide, and chemical vapour deposition onto metal surfaces. The latter is certainly suited to mass production, and the former possibly so.

Roelver cautioned that graphene-based sensor applications will require 5-10 years before they can compete with established technologies. This is due to the current lack of large-scale wafer-based and transfer-free synthesis techniques.

Various substrates were considered by the Bosch and Max-Planck researchers, who in the case of their magnetic sensor settled on hexagonal boron nitride. This is for reasons of both cost and technical performance.

Bosch's magnetic sensors are based on the Hall effect, in which a magnetic field induces a Lorentz force on moving electric charge carriers, leading to deflection and a measurable Hall voltage. Sensor performance is defined by two parameters: (1) sensitivity, which depends on the number of charge carriers, and (2) power consumption, which varies inversely with charge carrier mobility. It is high carrier mobility that makes graphene useful in such applications, and the results achieved by the Bosch-led team confirm this.

Comparing and contrasting materials, Roelver in his Graphene Week presentation showed that the worst case graphene scenarios roughly match a silicon reference. In the best case scenario, the result is a huge improvement over silicon, with much lower source current and power requirements for a given Hall sensitivity. In short, graphene provides for a high-performance magnetic sensor with low power and footprint requirements.

In terms of hard numbers, the remarkable result shown by Roelver

centred on a direct comparison between the sensitivity of a silicon-based Hall sensor with that of the Bosch-MPI graphene device. The silicon sensor has a sensitivity of 70 volts per amp-tesla, whereas with the boron nitride and graphene device the figure is 7,000. That is a jaw-dropping two orders of magnitude improvement, hence the reaction in the Graphene Week conference hall.

After summarising this stunning research result, Roelver concluded on a high note, stressing that Bosch takes graphene very seriously indeed as a future commercial technology.

"We are pleased to see that Graphene Week has been chosen as the forum to disclose such an important technological milestone," says Andrea Ferrari, chairman of the Executive Board of the Graphene Flagship. "Bosch's call for large-area integration of graphene into industrial processes fully matches and validates the flagship's planned investments in this critical area for the mass production of devices."

Provided by Graphene Flagship

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