metals. Even when the roles of the two antiferromagnetically coupled magnetic sublattices in the structures were played solely by transition metals, HD-AOS was observed, and as such the authors report the first successful demonstration of HD-AOS in rare-earth-free heterostructures.

The work by Mangin and colleagues is a remarkable contribution for understanding the mechanisms of optical control of magnetism in magnetic metals. The formulation and experimental verification of three rules to design a magnetic medium suitable for optical control of its magnetic state will drive further development of the theory of femtosecond optical control of magnetism. The possibility of designing a medium exhibiting HD-AOS provides practically limitless opportunities for fundamental studies of ultrafast optical control of magnetism. Moreover, the rare-earth-free heterostructures developed by Mangin *et al.* are compatible with modern magnetic recording and magnetic random access memory technologies, including heat-assisted magnetic recording in which sub-100 nm domains are recorded with the help of laser-induced heating. This compatibility sets an excellent starting point for applied research and development of novel technologies based on the optical control of magnetism. ❐

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Published online: 16 February 2014

MATERIAL WITNESS

GRAPHENE FINDS ITS PLACE

PHILIP BALL

If the commercial world is Darwinian, it's not in the sense of being a battle for supremacy. Companies, like species, coexist precisely because they don't always simply compete to be the biggest, but instead often content themselves with finding a niche. So just as the first advice for any entrepreneur would be "don't try to beat Google/Apple/Amazon", so the equivalent message for advocates of new electronic materials is "don't pretend you're the new silicon." That lesson has been amply learnt in organic electronics, where semiconducting materials initially predicted to rival the central fabric of microelectronics now instead play to their strengths for applications in optoelectronics, display technologies and interfacing with biology.

So it is with graphene. The story in which silicon is at the limits of its potential and this new contender waits to be (literally) rolled out as a cheap, robust and superior replacement is all too easily written. But no one in the field now doubts that, at least in the foreseeable future (and its fascinating fundamental physics aside), graphene must find niche applications if it is to justify all the excitement, not to mention all the funding.

But 'niche' doesn't mean small or trivial. A common consensus is that the possibilities of graphene in microelectronics are probably most profound in the burgeoning area of radiofrequency (rf) devices[1] — which means mobile devices such as smart phones, tablets and wearable electronics, as well as smart sensors and tags. Here the advantage of graphene as the substrate for charge conduction is its very high carrier mobility, which can be two orders of magnitude greater than that of silicon. This means that graphene field-effect transistors (GFETs) can be switched very fast, operating at the gigahertz speeds demanded in rf applications. Graphene's lack of a bandgap, which makes GFETs poor prospects for digital electronics because they can't be fully switched off[2], is no longer a hindrance here: rf electronics, for example to make radio receivers and amplifiers, can be an analog technology for which complete switch-off is not essential.

Much of the pioneering work in developing graphene rf circuits has happened in the IBM laboratories at Yorktown Heights in New York[3–5]. A team there has previously made GFETs from epitaxial graphene on silicon carbide that can operate at up to 100 GHz (ref. 4), and has fashioned such transistors into an integrated circuit that operates as a rf mixer[5].

That, however, was merely a proof of concept. In particular, the processing needed to complete the circuit after putting the GFETs in place degraded their performance. That's why an improvement in the manufacturing process now reported by the IBM team should be significant[6]. By making the fabrication of the GFETs the last stage in the process, they can use conventional methods without harming the delicate carbon films. That not only gives an improvement in gain performance of about four orders of magnitude but makes the whole process fully compatible with industry standards. The circuit acts as a rf receiver, capable of wireless communication at 4.3 GHz. Inevitably, the digital text used to demonstrate successful reception encoded a three-word message: 'I-B-M'. ❐

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