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TECHNOLOGY UPDATE

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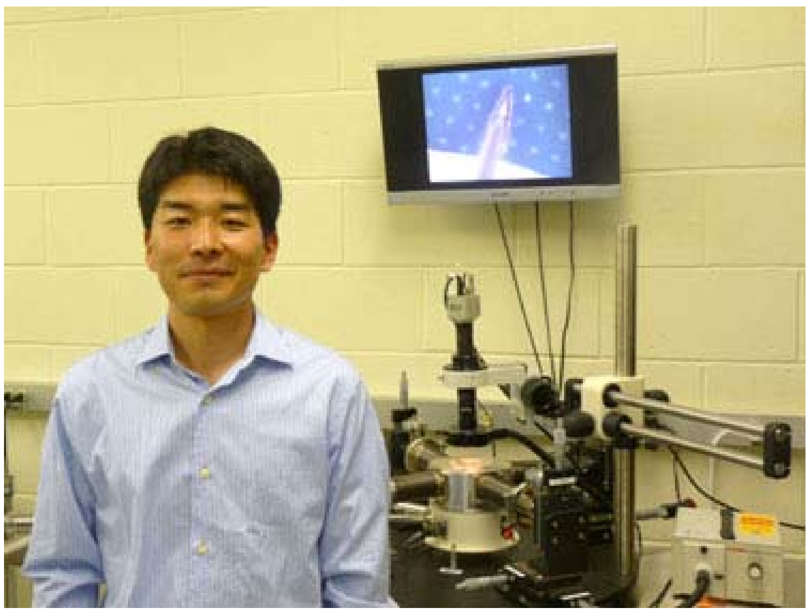
Reduced graphene oxide makes good field emitter

Researchers in the US, Japan and the UK have observed extremely low-threshold field electron emission from atomically thin edges of reduced graphene oxide. The interference pattern of the emitted electrons also suggests that the emitted electron beams are coherent, a result that could be important for making new electron sources for e-beam lithography, X-ray tubes, microwave amplifiers and even rocket thrusters.



(http://images.iop.org/objects/ntw/news/10/7/2/image1.jpg)
In the lab (http://images.iop.org/objects/ntw/news/10/7/2/image1.jpg)

Most electron emitters such as X-ray sources use thermal excitations – or thermionic emission – to generate high-current electron beams. However, such sources are far from ideal because they are unstable and bulky, and heat up their surroundings. Cold cathode emitters that remain at room temperature and provide high emission current density at low electric fields are thought of as being much better alternatives. Carbon nanotubes and other carbon-based materials are promising in this respect because they are bright field emitters and the electron beams that they emit have a low energy spread. Such properties make them particularly attractive for advanced high-resolution applications, for instance.

Linear electron source

Now, Manish Chhowalla of Rutgers University in the US, and colleagues in Japan and the UK, have discovered that reduced graphene oxide (rGO) is also a good low-threshold field emitter.

This material is also unique in the fact that it is the first linear electron source of its kind, unlike all previous such devices that were point sources. Although point sources do show low-threshold emission thanks to local field enhancement at the point tip, working with these emitters can be difficult in practice because they need to be positioned sufficiently apart for good field enhancement. This limits the number of emission sites and inevitably the overall current.

"Our results on rGO provide evidence of emission sites that are just a few nanometres apart, something that offers prospects for novel applications," team member Hisato Yamaguchi told *nanotechweb.org*.

The work could also help scientists better understand the fundamental physics of linear electron sources, he adds.

Nanometre resolution

The researchers conducted their field emission experiments by applying a bias voltage between a cathode made of rGO and the imaging anode plate, which was positioned perpendicular to the cathode plane to ensure that the electron emission occurred only from the rGO edge. The results show how much electric field is needed to extract electrons from the cathode while mapping out the position and pattern of the emitted electron beams with nanometre spatial resolution.

According to the team, the work could be important for e-beam lithography with nanometre spatial resolution, X-ray tubes, microwave amplifiers and even rocket thrusters. "Rocket thrusters for small spacecraft that utilize field-emitted electrons as a propulsion force have been one of the active research areas in the field of space applications," said Yamaguchi. "rGO could be a very attractive candidate here."

Chhowalla and colleagues now plan to fabricate high-performance electron emission devices with low-threshold drive voltage and high current density by aligning rGO sheets. "We also hope to investigate how good these emitters actually are as electron sources for nanometre resolution e-beam lithography," revealed Yamaguchi.

The work was reported in *ACS Nano*.

About the author

Belle Dumé is contributing editor at *nanotechweb.org*.