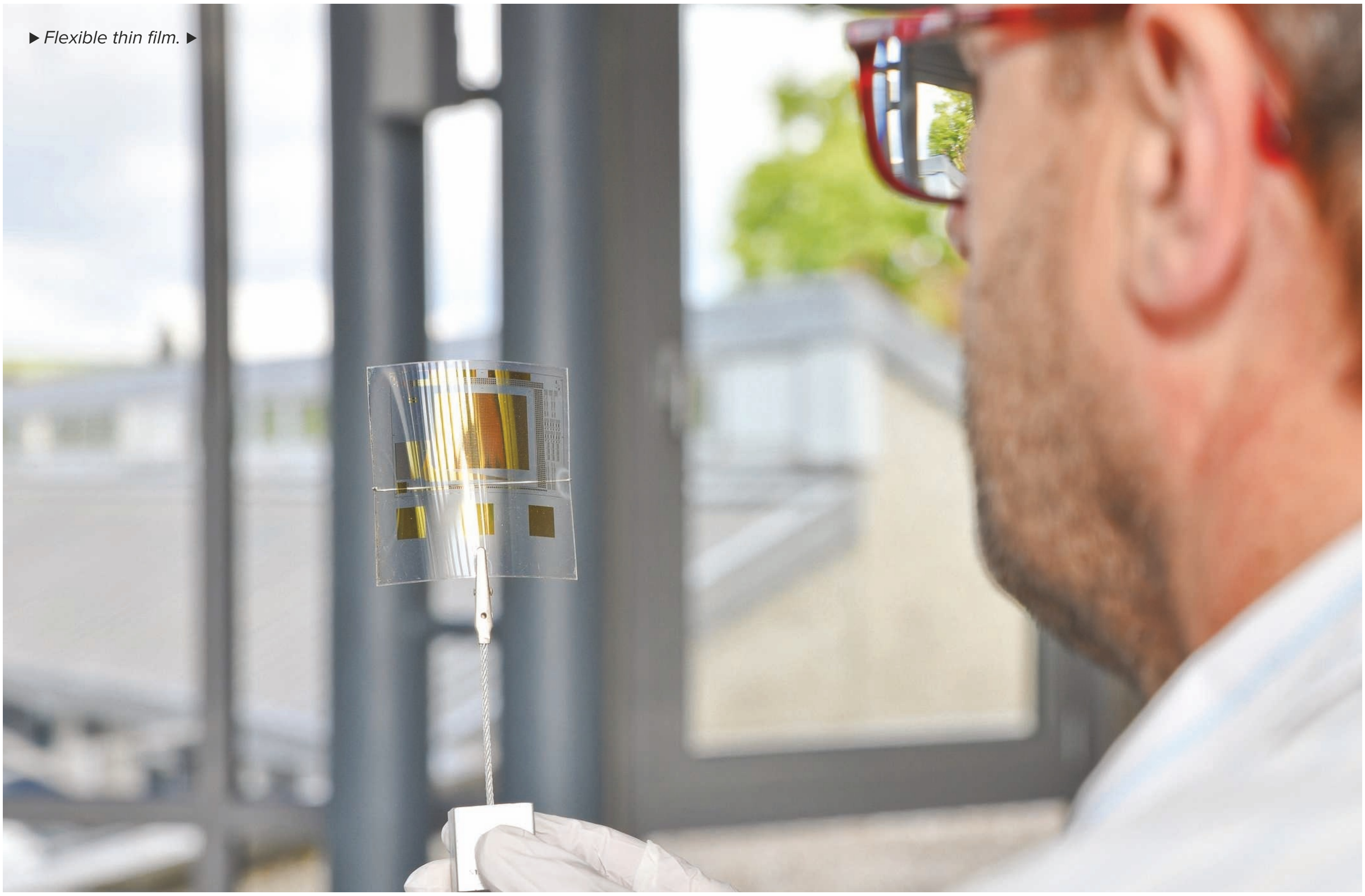
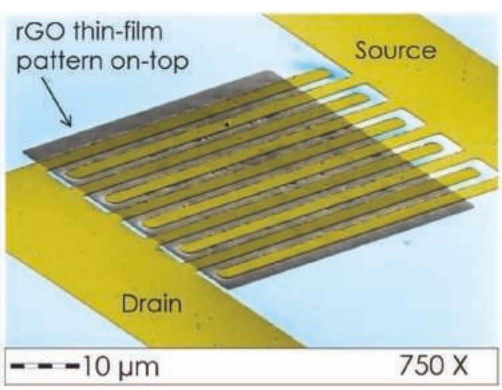
Fraunhofer ILT uses Coherent's LineBeam 155 excimer laser processing system to help enable scalable graphene production



▶ *Flexible thin film.* ▶



▶ *A microscope image of a reduced graphene oxide (rGO) electrode.* ▶

The Germany-based Fraunhofer Institute for Laser Technology (ILT) and Coherent, a US-based manufacturer of lasers and laser systems, have entered a collaboration that involves the Fraunhofer ILT using Coherent's LineBeam 155 excimer laser processing system to help enable scalable graphene production.

The institute's Micro and Nanostructuring Group selected the LineBeam 155 to aid its research into the photoreduction of monolayer graphene oxide (GO) films, particularly for electric vehicle batteries (EVBs).

Graphene is a single-layer nanomaterial consisting of carbon atoms in a hexagonal lattice. It possesses a unique combination of properties, namely high electrical and thermal conductivity, excellent transparency at visible wavelengths, and exceptional mechanical strength. Graphene therefore has the potential to, for example, enhance the transparent conductive electrodes employed in flexible electronics and organic light-emitting diode (OLED) displays, and improve the energy density and charging characteristics of lithium-ion batteries for use in a range of products, from mobile phones to electric vehicles.

Scalable graphene production for standard micro- and nanofabrication processes is crucial in the advancement of the aforementioned technologies toward industrial applications. There are several methods for achieving this being studied. One such method involves the reduction of graphene oxide monolayer films that are spin-coated on either silicon/silicon dioxide (Si/SiO_2) or glass wafers. The reduction can be achieved thermally, chemically or through photoreduction, the last showing the greatest promise. Photoreduction involves exposure to laser light in the presence of an ultra-high purity inert gas or in vacuum.

The pulsed krypton fluoride (KrF) excimer laser is ideal for photoreduction of monolayer GO films for two reasons. Firstly, the deep-ultraviolet (DUV) 248 nm photons produced by the laser are more strongly coupled into the material than those that have longer wavelengths, resulting in a high level of non-thermal desorption and therefore efficient, non-destructive photoreduction. Secondly, the output of the laser lends itself to being formed into a long, thin line beam, thus enabling rapid processing of large areas of material.

It is because of these reasons that the Fraunhofer ILT's Micro and Nanostructuring Group opted for the LineBeam 155. The system combines Coherent's LEAP 150K KrF excimer laser, which has a maximum average output of 150 W at 248 nm, and LineBeam optics, which deliver a 155 mm x 0.4 mm flat-top beam to the surface. Part motion of the irradiated material enables surface treatment up to 5,500 cm^2 per minute. Alternatively, the laser output can be directed into a high-resolution mask ablation system for micropatterning applications. By varying the system's laser power, pulse repetition rate and scan speed, a wide range of precision photoreduction, microstructuring, ablation and processing tasks can be performed on various materials.

Matthias Trenn of the Micro and Nano Structuring group commented: "The LineBeam system is a unique tool that allows us to deliver high energy pulses of ultraviolet light with extremely precise dosage control, combined with rapid, large area processing. This gives us the ability to produce graphene films, hopefully faster and more efficiently than possible by any other method, and is therefore very valuable in our work."

Ralph Delmdahl, excimer product marketing manager at Coherent, added: "LineBeam systems have already proven themselves in mobile device production. We're excited that they may bring the same benefits to another important developing technology, namely more efficient and higher capacity batteries, particularly for e-mobility." ●

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