to 300 nm (corresponding to attolitre volumes) was achieved. This approaches some of the best results reported using nanocapillary nozzles[4,5], and greatly exceeds the possibilities provided by conventional inkjet methods.

The versatility of the pyroelectric approach to e-jet printing, the simplicity afforded by the absence of nozzles, electrodes or high-voltage power supplies, and the potential for high-speed printing collectively make the method very attractive for many applications. Opportunities for future work seem to lie in developing methods for preparing optimized configurations of the ink (for example, controlling the size of the droplets or the thickness of the films) for printing and for replenishing this ink as it is consumed during printing. The physics of thermal diffusion and related processes that determine the upper limits in patterning speeds might also be interesting to explore.

As an alternative to pyroelectrics for generating local fields, one could also consider programmable arrays of patterned electrodes or scanning metal probes as routes to virtual nozzles. Pursuing these possibilities, exploring advanced inks and exploiting the capabilities for applications in biology, printed electronics and related areas all represent promising directions for further research. ❐

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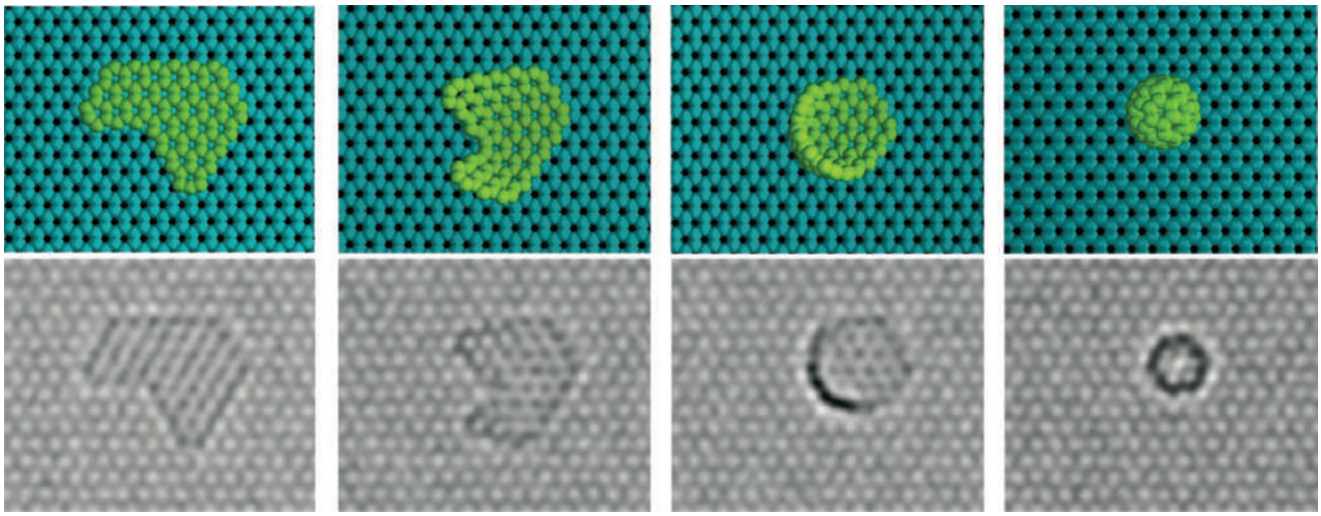
FULLERENE SYNTHESIS

# Caught on camera



Graphite is routinely transformed into fullerene $C_{60}$ molecules with the help of lasers or electric arcs, although the exact mechanism by which these spherical carbon structures are formed is still unclear. Andrey Chuvilin, Andrei Khlobystov and colleagues at the universities of Ulm and Nottingham have now directly imaged the formation of fullerene molecules from graphene (a single layer of carbon atoms) with an aberration-corrected transmission electron microscope (*Nature Chem.* **2,** 450–453; 2010).

The Ulm–Nottingham team fired an 80-keV electron beam at their starting material, exciting the carbon atoms and fragmenting the graphene sheet into smaller flakes. These flakes underwent a series of further changes before finally forming a spherical fullerene molecule that seemed to roll back and forth on the graphene substrate below. The high-resolution imaging was supplemented with quantum mechanical modelling, which helped the team determine the formation mechanism.

The figure shows models (top) and simulated electron-microscopy images (bottom) of key stages in the mechanism. Chuvilin, who is now at the nanoGUNE laboratory in Spain, and colleagues found that the electron beam removed carbon atoms from the edges of the graphene flakes (left), destabilizing the flakes and leading to the formation of pentagons (middle-left). This in turn caused the flakes to curl and form bowl-shaped structures (middle-right). Finally, the edges of the flakes were 'zipped up' to yield the fullerene molecules (right).

The conditions under which these molecules were formed is markedly different from those normally used for fullerene production, so 25 years after $C_{60}$ was first produced in the laboratory, there is still more to learn about the mechanisms used to produce it.

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