TWO-DIMENSIONAL MATERIALS

Organic semiconductor crystals go large and fast

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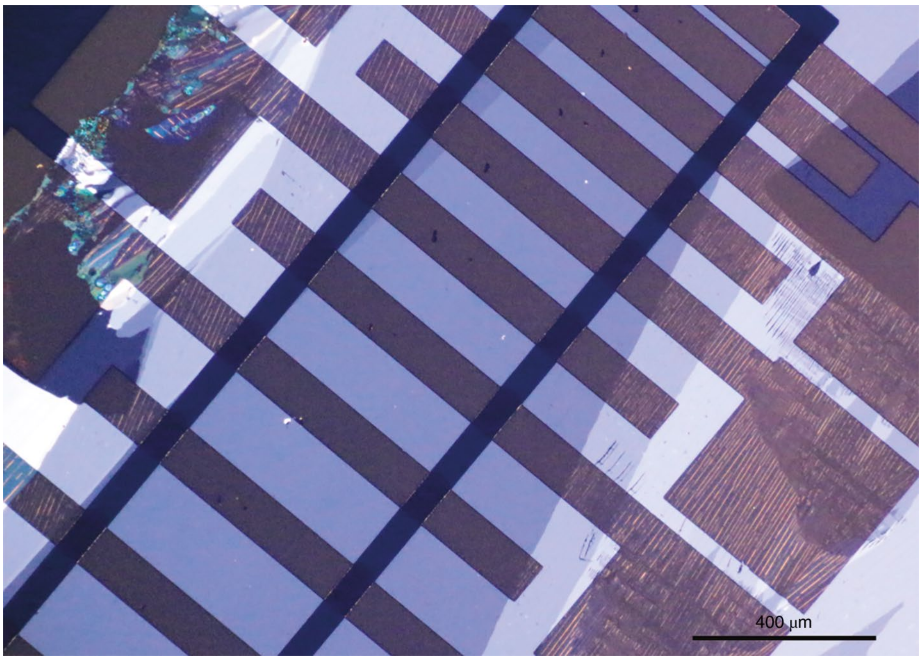

Credit: AAAS

The incorporation of two-dimensional materials, such as graphene or molybdenum disulphide, into various practical devices and applications will require the production of large-area films of high quality. Current fabrication methods typically offer limited control and can often damage the 2D structure of the material. An alternative strategy is to use organic semiconductors that can form quasi-2D crystals in which the molecules are held together through weak van der Waals interactions. However, these materials generally suffer from poor electronic performance. Toshihiro Okamoto, Jun Takeya and colleagues now show that a solution-based process can be used to fabricate wafer-scale organic single crystals with high mobility.

The researchers — who are based at several institutes in Japan — fabricated the crystals using an optimized meniscus-driven technique in which a coating tool is used to grow the crystalline films. In particular, a droplet of solution containing the organic semiconductor molecules is held between a substrate and a blade, and when the solvent in the droplet evaporates, the crystals form. Various parameters, including temperature, evaporation rate and solvent choice, affect the quality of the film and provide control over its thickness.

Takeya and colleagues optimized the fabrication conditions and successfully produced monolayer, bilayer and trilayer molecular single crystals. Using the bilayer materials, they built organic field-effect transistors that exhibit mobilities as high as 13 $cm^2 V^{-1} s^{-1}$ and very low contact resistances, which led to high-speed transistor operation. They also showed that diode-connected transistors could function as high-speed rectifiers.

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