NEWS & VIEWS

processing of both small molecules and polymers offers the possibility of achieving simplicity and low cost. Polymers⁸ are clearly more amenable to thin-film formation, and solutions can be formulated with the viscosity and other properties needed for printing. However, thin films typically have significant regions of disorder, because film formation is usually a rapid, kinetically driven process. This can be a limiting factor in the performances that are achieved.

Crystallization of small molecules on a substrate cast from solution often results in the formation of polycrystalline thin-film domains typified by poor grain connectivity and suboptimal crystalline ordering. In some cases, a further heat treatment can thermodynamically drive the system to a more ordered morphology, bringing performance to a level close to that of an optimized film grown by evaporation. There are also some encouraging results on solution-processable pentacene derivatives⁹. The method reported by Stingelin-Stutzmann and coworkers may bring us a step closer to being able to achieve the ostensibly incompatible combination of solution processing and optimized crystallisation.

The authors used an understanding of the physical chemistry of a binary eutectic (low-melting) mixture to optimize the crystallinity of a solutionprocessed semiconductor film. The approach involved thermodynamically manipulating the crystallization of the thin film by blending a small-molecule semiconductor with a vitrifying additive to hinder crystallization, and a small amount of a film-forming high-molecular-weight polymer. A phase diagram was constructed to optimize the blend composition, and, through post-fabrication thermal treatment, control the film morphology. The vitrifying component prevented uncontrolled crystallization of the semiconductor as the solvent evaporated and the initial film formed, providing the scope for subsequently more-controlled crystal formation. When the films were processed, this elegant and versatile method produced semiconductor devices from solution with performance comparable to evaporatively deposited ones. The wide variety of combinations of stable, high-performance semiconductors, vitrifying diluents and polymer additives available for use in this approach suggests that further improvements in semiconductor performance and reduced processing temperatures can be expected.

Several open issues remain before the commercial exploitation of organic electronics can begin in earnest. Based on current projections, circuitry and components are likely to be fabricated on a commercial scale from predominantly additive, continuousprinting technologies¹⁰. Issues such as throughput, resolution, and three-dimensional alignment of individual circuit components within multilayer devices by sequential printing steps must be considered in such technologies¹¹, and it is likely that we will need a combination of printing techniques to pattern the range of materials and their different feature sizes within the devices. Any developments in the field of materials processing that are intended to be used in such commercial applications need to be compatible with these methods.

Identification of entry-level and mass-market devices and their performance requirements are clearly an additional question. For example, OFET backplane switching elements to drive a lowresolution, conformable electrophoretic, or e-paper, displays may only require moderate performance - comfortably within the specifications of a range of evaporatively deposited semiconductors and solutiondeposited polymers. At the more challenging end of the display technology spectrum, a full-colour, flexible display operating at speeds consistent with video rates and consisting of OLEDs driven by OFETs potentially offers complementary benefits of both the key emissive and driving functions being fabricated by printing techniques. However, this device will require transistors with charge-carrier mobilities at least two orders of magnitude higher than the e-paper display. This target can probably be achieved with an evaporated semiconductor, but would currently be extremely difficult with solution-processed semiconductors. Stingelin-Stutzmann and colleagues' results can provide us with some optimism that this target is not out of reach.

REFERENCES

- 1. Stingelin-Stutzmann, N. et al. Nature Mater. 4, 601–606 (2005).
- 2. Chabinyc, M. L. & Salleo, A. Chem. Mater. 16, 4509-4521 (2004).
- 3. Gelinck, G. H. et al. Nature Mater. 3, 106-110 (2004).
- 4. Katz, H. E. Chem. Mater. 16, 4748-4756 (2004).
- Jurchescu, O. D., Baas, J. & Palstra, T. T. M. Appl. Phys. Lett. 84, 3061–3063 (2004).
- Podzorov, V., Sysoev, S. E., Loginova, E., Pudalov, V. M. & Gershenson, M. E. Appl. Phys. Lett. 83, 3504–3505 (2003).
- 7. Baude, P. F. et al. Appl. Phys. Lett. 82, 3964-3966 (2003).
- 8. Sirringhaus, H. et al. Nature 401, 685-688 (1999).
- Payne, M. M., Parkin, S. R., Anthony, J. E., Kuo, C. C.& Jackson, T. N. J. Am. Chem. Soc. 127, 4986–4987 (2005).
- 10. Ling, M. M. & Bao, Z. Chem. Mater. 16, 4824-4840 (2004).
- 11. Sheats, J. R. J. Mater. Res. 19, 1974-1989 (2004).
- 12. Sundar, V. C. et al. Science 303, 1644-1646 (2004)

ERRATUM

INFINITE NETWORKS OF SURFACES

ROBERT HOLYST Nature Materials **4**, 510–511 (2005).

In this News and Views article, the sentence "Probably the subject would have slipped into oblivion, were it not for the experimental discovery, by Luzzati and Spegt, of the gyroid phase in soap solutions, in 1967." should have read "Probably the subject would have slipped into oblivion, were it not for the experimental discovery, by Luzzati and Spegt, of a mesophase with the same symmetry as the gyroid in a dry system of soap, in 1967." In addition, on the same page, the reference to the fourteenth century was incorrect, it should have said the nineteenth century.