editorial

Plastic affinity

A new surface functionalization method opens the way towards high-performance organic electronic devices on flexible substrates.

Organic semiconductors exhibit many attractive traits, such as their low-cost, solution processability, transparency and mechanical flexibility. They could fulfil various electronic functionalities on almost any substrate rather than being limited to the rigid Si-wafers used in traditional integrated circuits. For example, commercial organic light-emitting diodes[1] (OLEDs) that have recently emerged as a strong flat-panel display technology are fabricated on transparent glass substrates, whereas organic thin-film transistors (OTFTs) can be realized on traditional Si/SiO_2 and plastic substrates alike.

Low field-effect mobility of organic semiconductors has inhibited the commercial debut of OTFTs. Following the progress made towards synthesizing high-mobility organic polymers and small molecules, several materials with mobility superior to amorphous silicon[2,3] have been successfully demonstrated. However, until now the best performing OTFTs have been almost exclusively fabricated on Si, which, unlike plastic substrates, ensures a higher quality of the semiconductor–dielectric interface. In a transistor fabricated on doped silicon wafers, charge trapping at the semiconductor–SiO_2 interface is known to cause performance deterioration, but this issue can be readily circumvented by surface functionalization with self-assembled monolayers (SAMs). Surface passivation with SAMs effectively lowers the dielectric surface energy and reduces the interface trapping density, resulting in OTFTs with improved characteristics, but it is not applicable for plastic substrates and, therefore, for flexible electronic devices.

On page 139, Yokota et al. present an alternative passivation method that works on arbitrary surfaces including polymers and has been demonstrated to improve the performance of flexible OTFTs in a way similar to high-quality aliphatic SAMs on inorganic oxides. The approach is based on recently developed two-dimensional triptycene films[4] that serve as part of a dielectric layer but unlike other SAMs do not require specific covalent bonding sites. That is to say, the fabrication of high-quality OTFTs with reproducible characteristics is no longer limited to rigid silicon but can be obtained on any flexible substrate, providing the benefit of the significantly extended functionality of organic electronic devices and circuits. Thus, it is now possible to fabricate both p- and n-type OTFTs as well as complementary inverters and ring oscillators with excellent static and dynamic performance on arbitrary substrates. ❐

Published online: 5 February 2018
https://doi.org/10.1038/s41565-018-0077-3

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A cool paper

Interdisciplinarity highlights the uniqueness of nanoscience.

When assessing manuscripts, we ask ourselves whether a large chunk of researchers in nanoscience and nanotechnology will be able to appreciate the findings. This goal can be achieved through a combination of conceptual advances, mechanistic insights and technological implications. But the uniqueness of nanotechnology is also its interdisciplinarity, and when all of these components come together a manuscript can really fly. One such example is the paper by Cui et al. on page 122 of this issue.

It reports refrigeration (Peltier cooling) in molecular junctions. There are a number of aspects that made this manuscript stand out when it landed on our desks.

First of all, the work is truly interdisciplinary. Physicists and chemists, experimentalists and theoreticians came together to develop an experimental platform that allows the relationship between heating or cooling and the charge transmission properties of molecules to be investigated. This interdisciplinarity is what has made nanoscience special since the beginning, but it is probably now, more than ever, that the tools of top–down nanofabrication are getting enticingly close to the molecular scale, enabling a more intimate cooperation between physicists and chemists. Ironically, as in this paper, it is sometimes the nanogap rather than the nanostructure itself that is most interesting to study.

Second of all, the paper describes a novel instrument, a very sensitive calorimeter, capable of detecting the total heat absorbed or dissipated in the junction under a bias voltage with picowatt sensitivity. Any reader educated in general science can appreciate the tricks the researchers used to achieve such a feat.

Third of all, the paper represents the experimental verification of the theoretical prediction of refrigeration in molecular junctions, following the estimate that some molecules can exhibit large thermopower (Seebeck coefficient) and therefore high thermoelectric power conversion efficiency.

Of course the final decision on publication was taken only after formal peer-review. The experts were already impressed in the first round of review and in the end the manuscript was accepted just two months after submission.

It is unlikely that the paper will have immediate practical implications. As Keehoon Kang and Takhee Lee explain in the accompanying News & Views (on page 97), "…many advances and optimizations are needed before thinking of any practical implication." However, our remit is to report exciting results in both technology and science at the nanoscale, and papers like that by Cui et al. are good examples of the more fundamental aspects that we aim to publish. ❐

Published online: 5 February 2018
https://doi.org/10.1038/s41565-018-0078-2