electrons (to the right). The surface layer prevents front surface recombination. The layer to the right of the IB region is a blocking layer that prevents the passage of electrons from the IB to the CB by tunnelling.

Although the need for this blocking layer is well-understood and already used in QD-IB solar cells[9], its application to alloy-based IB materials — one determining factor for producing a working IB solar cell in a bulk material — has so far been difficult to achieve. The cell developed by López *et al.* has an open-circuit voltage of 0.92 V at room temperature and an illumination of 20 Suns, which far exceeds the reference cell's open-circuit voltage of 0.42 V.

López and co-workers complete their demonstration by discussing how the two thresholds in the external quantum efficiency of their cell — situated at 1.1 eV and 2 eV — reveal the VB→IB and VB→CB transitions. The IB→CB threshold is not visible, but this is to be expected from the way in which the experiment was performed. The only threshold visible in the test cell is the VB→IB transition, proving that both the IB and the CB are short-circuited through the GaAs substrate. Note that a two-photon experiment[9] must be performed to give additional confirmation regarding the IB operation.

The QFL splits are not illustrated in the original figures of López *et al.* The amount of QFL splitting, which ultimately determines the output voltage, can be visualized by qualitatively modifying the energy bands of the original figure to illustrate operation of the cell under illumination, as shown in Fig. 1b. In fact, one of the key features revealing the QFL splitting between the CB and the IB was that radiative recombination occurs between the CB and the IB, allowing the cell to behave like a light-emitting diode. Although the IB→CB threshold was not visible from measurements of the external quantum efficiency, the researchers observed the light-emitting diode effect by directly measuring, for the first time in an IB solar cell, the CB→IB electroluminescence. They observed an energy peak at 0.9 eV originating from radiative recombination between the CB and the partially occupied IB, which exists only when there is QFL splitting between the CB and the IB. This key result is evidence of the optical transitions between the CB and the IB, giving the missing link towards developing a working IB photovoltaic device.

The external quantum efficiency of the cell containing a blocking layer was around an order of magnitude lower than that of the cell without a blocking layer. This resulted in a lower current, which clearly loses the advantage of high current in IB solar cells. The fact that the external quantum efficiency is low for both the VB→CB and VB→IB transitions in the cell with a blocking layer suggests that the problem is not low photon absorption but difficulty in extracting the current, possibly because of the blocking layer itself. This important issue requires further investigation.

Although the efficiency of this cell is still far from promised levels, the work of López *et al.* represents a significant step forwards in both the efficiency and our understanding of IB solar cells. ❐

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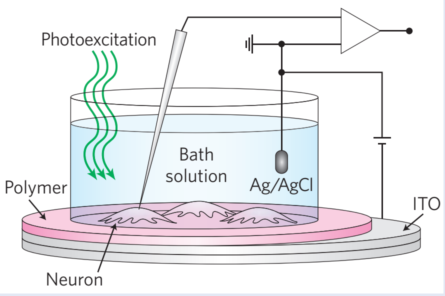
BIOPHOTONICS

Neural optoelectronic interface

The realization of an organic biocompatible artificial retina for restoring lost vision could now be one stage closer to reality, thanks to a hybrid device that successfully integrates nerve cells from a rat's brain with polymer optoelectronics.

Writing in *Nature Communications* (doi:10.1038/ncomms1164), Guglielmo Lanzani and co-workers from Istituto Italiano di Tecnologia and Politecnico di Milano in Italy show that it is possible to grow hippocampal neurons on top of an organic photodetector to create a functional interface. A visible light pulse striking the photodetector directly beneath a neuron generates an electrical charge that changes the neuron's ionic local environment, causing it to fire. In essence, this conversion of light into a neural signal exactly mimics what happens in a healthy retina.

The photodetector developed by Lanzani and co-workers consists of a



polymeric light-sensitive film made from rr-P3HT:PCMB, a fullerene–polythiophene blend commonly used in organic solar cells. The researchers cover one side of the film with indium tin oxide (ITO) to form a transparent electrode, and the other with neurons surrounded by an aqueous salt solution, which keeps them alive for up to 28 days.

According to the researchers, patch-clamp experiments recording neuron activity showed that a train of short visible light pulses (20 ms duration, 1 Hz repetition rate) reliably triggered action potentials. The triggering was shown to be spatially confined to the region fully illuminated by the light.

The most obvious application of this research is for the creation of a new form of organic artificial retina. Although silicon photodetectors have already been proposed and tested for use as an artificial retina, Lanzani and co-workers say that an organic approach brings several benefits. First, it works without any externally applied electric field and with minimal heat dissipation. Second, organic optoelectronics can be fabricated cheaply by methods such as ink-jet deposition, thereby allowing the creation of thin, flexible devices that are well-suited to implantation in the eye.

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