CENTRE D'INVESTIGACIÓ EN NANOCIÈNCIA I NANOTECNOLOGIA
CAMPUS UAB. BELLATERRA. BARCELONA

PRESS RELEASE

Nanowires as future transparent electrical contacts for organic optoelectronic devices

- **Nanowires provide the solution to overcome the trade-off between electrical conductivity and optical transparency for organic light emitting diodes and photovoltaics.**

- **Branched ITO nanowires of diameters below 60 nanometres prove to be an excellent top contact for inorganic light emitting diodes up to the near infrared.**

Bellaterra (Barcelona), Spain, march 9th, 2009. A team led by Clivia Sotomayor Torres, ICREA Research Professor and Leader of the Phononic and Photonic Nanostructures Group at the Centro de Investigación en Nanociencia y Nanotecnología, CIN2 (ICN-CSIC) has shown that Nanowires provide the solution to overcome the trade-off between electrical conductivity and optical transparency for organic light emitting diodes and photovoltaics.

CIN2 is a mixed centre joined by Institut Català de Nanotecnologia (ICN), whom the mentioned group belongs to, and the Consejo Superior de Investigaciones Científicas (CSIC).

From this research, the article "**Bottom-up growth of fully transparent contact layers of indium tin oxide nanowires for LEDs"** has been published on line on 1st February 2009, March Issue of Nature Nanotechnology, DOI: 10.1038/NANO.2008.418.

Transparent conducting oxides (TCO) play a crucial role in a range of passive and active optical and energy devices. They are used for transparent anti-reflecting coatings, electrodes in solar cells, Li-ion batteries and flat-panel displays. However, they are far from ideal. For example, as electrical contacts for organic light emitting devices (OLEDs) and prospective organic photovoltaics (OPV), they are required to conduct electric current and at the same time be transparent to the frequencies of the emitted light, in the case of OLEDs, or absorbed sun light, in the case of OPV. These two needs are usually conflicting due to losses by light absorption in a sufficiently thick and uniform layer needed for conduction and a thin one needed for transparency. This usually results in a trade off.

Clivia Sotomayor Torres together with Colm O'Dwyer of the University of Limerick (Ireland), Vladimir Lavayen of Universidad Técnica Federico Santa Maria (Chile)/UNIFRA (Brazil), Marta Szachowic and Giuseppe Visimberga of University College Cork, Tyndall National Institute (Ireland) and Simon Newcombe of Glebe Scientific Ltd (Ireland), have shown that this compromise is no longer necessary. By growing crystalline branched nanowires of Indium Tin Oxide (ITO) with sub- 60 nm diameter in the form of a layer, they demonstrated that both electrical conductivity and transparency can be optimized in the visible and the near-infrared part of the spectrum.

At the centre of this breakthrough is the nanowire structure of ITO. Single phase ITO nanowires evolved from seed, through nucleation, growth with progressive branch seeding and further growth. The team studied the growth phase diagram to determine optimum conditions going from a porous, rough but compact layer of ITO to dendritic nanowires.

The team measured optical properties and determined that the refractive index of the electrical contact layer composed of nanowires is close to unity, i.e., close to the refractive index of air. This means that the Fresnel reflection, which affects thicker and more compact ITO films, is dramatically reduced in branched nanowire structures. Important practical implications are that light emitted from a LED with such a top TCO contact is isotropic and suffers minimum losses thereby enhancing the extraction efficiency. The room temperature electrical conductivity of branched nanowires is just above 1 S/cm, which is comparable to that of individual wires and two orders of magnitude larger than that of individual In2O3 or SnO2 nanowires. Optimising further the growth conditions, it is expected that the sheet resistance can be four orders of magnitude larger than that of commercially available TCO. Charge transport mechanisms are undergoing further studies.

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This nanotechnology research goes to show that nanowires have much to offer with their enhanced electrical and optical properties in areas of fast technological development, such as those driven by the pressing energy challenges. Understanding the nanometre-scale science behind will be crucial to find alternatives to ITO nanowires as TCO, since the Indium reserves are rather limited and the demand for organic optoelectronic devices is soaring. This work is a solid step in this direction.

Reference

Bottom-up growth of fully transparent low refractive index top-contact layers of indium tin oxide nanowires for LEDs

C. O'Dwyer, M. Szachowicz, G. Visimberga, V. Lavayen, S. B. Newcomb, and C. M. Sotomayor Torres,.

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