Strategic raw materials

New indium-free transparent conducting oxides (TCOs)

At a glance

The transparent conductor industry - a major provider for flat panel displays - is dominated by indium tin oxide (ITO), which holds more than a 90% share of the high-end transparent conductor market.

ITO is brittle and its indium content rare and therefore costly. Manufacturers are looking to the urgent development of new, indium-free transparent conducting oxides (TCOs) with highly sustainable, low cost and environmentally-friendly materials.

Work has been undertaken at the University of Liverpool to develop a competitive alternative to ITO, with several indium-free compositions studied as potential new TCO candidates. The work is designed to maximise opportunities for pursuing the high growth – and development opportunities – that characterise the surging transparent conductor market.

Challenge

Transparent conducting oxides (TCOs) are doped metal oxides which have a remarkable combination of conductivity and transparency. They are widely used in flat panel displays (FPD) and photovoltaic (PV) devices. To date, the transparent conductor industry is dominated by a single material – indium tin oxide (ITO).

Manufacturers have relied on this material for years but have always complained about ITO's brittleness and inability to meet their demanding and changing requirements. More importantly, indium, the primary metal in ITO, is rare and its price has increased considerably due to market demand. As a result, a number of alternative TCOs have been studied and found niche markets (such as for solar panels).

However, further improvement on the performance, as well as the development of deposition techniques for present alternative TCOs is required, so as to enable wider uptake in applications. Currently, ITO still has more than 90% share of the high-end transparent conductor market. It is therefore important and urgent to develop new, indium-free TCOs with highly sustainable, low cost and environmentally-friendly materials.

Approach

A pre-competitive project was carried out in the University of Liverpool to develop a competitive alternative to ITO. Several indium-free compositions were studied as potential new TCO candidates.

By band structure calculation with LMTO (Linear Muffin-Tin Orbital) method, one composition was chosen as a promising candidate for further investigation. It has a large direct band gap (> 4.5 eV) and wide conduction band. Based on the identified candidate, doped thin film samples will be prepared by combinatorial. Their electrical and optical performances will be characterized and the TCO material further optimised.

Solution

In general, TCOs should have greater than 80% optical transmittance of incident light as well as electrical conductivities higher than 103 S/cm. Across several departments - including Chemistry, Materials Science and Electrical Engineering - the University of Liverpool has expertise in materials design, synthesis, characterization as well as interaction with industrial partners, and is therefore is an ideally positioned to tackle this problem.

Moreover, an updated PLD (Pulsed laser deposition) facility has been developed, which allows the growth of combinatorial thin films conveniently with a multi-target system. High throughput (HT) characterization methods have also been developed.

Benefits

The total transparent conductor market is forecasted to slightly over US $3 bn. in revenues in 2011 - surging to over US $10 bn. in 2018. The market for ITO alternatives will be worth almost US $1.9 bn. by that time.

This work is designed to maximise opportunities for pursuing this high-growth market, as well as opening up new collaborative research/development and patenting opportunities.