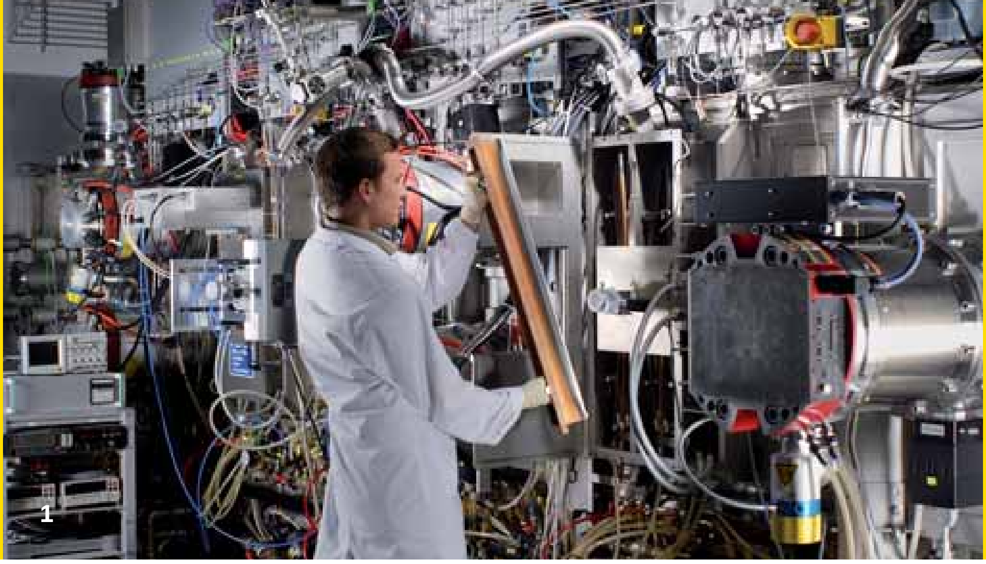

THE ICEFREE WINDSHIELD

Driving during the winter is sometimes not a lot of fun. One reason for this is fogged-up or icy windows. At the Fraunhofer Institute for Surface Engineering and Thin Films IST a new coating for automotive glazing which can help solve this problem is currently under development. The transparent film is as conductive as a metal – the glass thus becomes a heat reflector, which prevents the windshield from cooling down and icing over. There is thus no need for the lengthy process of heating the windows until they are clear - something which in the case of electric vehicles consumes a great deal of energy.

Preliminary work in the 1980s

The point of departure for our work was the results obtained back in the 1980s at the University of Uppsala for non-icing windshields based on transparent conductive SnO_2:F coatings produced by pyrolysis. A vehicle with a low-E coating remains completely free of ice while the uncoated windshield is significantly iced up. Unfortunately this technology could not be taken further since the coarse SnO_2:F coating proved to be very susceptible to wear and could not provide the stability required for use in the automobile. The present innovation is based on the fact that transparent conductive and thus low-emitting (low-E) films can be produced very inexpensively and with much better properties than those previously available. This new PVD coating which is applied at room temperature to glass is in particular not only flexible but also extremely resistant to chemical and mechanical stress. This means a marked improvement in its wear characteristics as compared with uncoated glass.

HIPIMS sputtering of TCOs

These property combinations were previously considered impossible and the key to achieving them lies in a new kind of process control, namely high power impulse magnetron sputtering (HIPIMS). With this method the sputtered material is ionized to a considerable extent. Researchers at the Fraunhofer IST have been able to demonstrate that at the transition to conditions with a maximum level of ionization, layers of nanocrystalline indium tin oxide (ITO) form which exhibit no grain growth even when the glass is bent at ~650 °C.

Coating properties

In the laboratory setup used at the Fraunhofer IST and manufactured by the Advanced Energy company, the current flow in the HIPIMS pulse derives from the capacity and charging voltage of the underlying capacitor bank. In addition, a regulatory device shortens the pulse duration so as to prevent marked arcing at the cathode. With both the 2.0 kV and the 2.5 kV charging voltages, layers which are almost X-ray amorphous are created first. After annealing at ~650 °C they show a sharply pronounced X-ray peak. This is a concomitant of a transition from the amorphous to the crystalline phase and does not occur with 3 kV charging voltage. Nanocrystalline layers already come into existence here, showing a broad peak in the Θ-2Θ diagram which is only changed to an insignificant extent by annealing. These layers have a grain size, as measured by X-ray diffraction, of only ~20 nm. Due to the Hall-Petch relation this nanocrystalline growth results in the layers hardening and in a higher thermal stability. The electrical and optical properties of the coatings correspond fully to those of conventional ITO coatings, the only difference being a higher layer resistance.

1 *Large-area coating at the Fraunhofer IST.*

Potential for practical application

The icefree windshield, which has been developed jointly with VW and Audi, offers a genuine safety-related innovation for the automotive sector. The electrical conductivity of the coatings does however dampen wireless communication. This means that some adjustment work will be necessary as regards GPS and cell phone aerials as well as emergency call systems. In the context of electromobility the technology receives a further boost in importance since here passive, energy-neutral solutions are required. What is very much not wanted is the need to heat up the vehicle interior at great expense and at the cost of the battery charge. Other user areas of application emerge from the transition to triple glazing in buildings. Here too improved insulation means more and more condensation on the outside of the glass panes, something our technology can efficiently prevent. The coating can also be used as a heating conductor: in chemical process engineering, for example, reactor vessels can be equipped with a transparent heating system. Completely new areas will also open up in the field of transparent oxidic electronics where the new technology offers ways – in combination with sol-gel p-TCOs for example – of creating transparent diodes and circuitry based on this.

[1]: I. Hamberg et al., Applied Optics 26 (1987) 2131

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