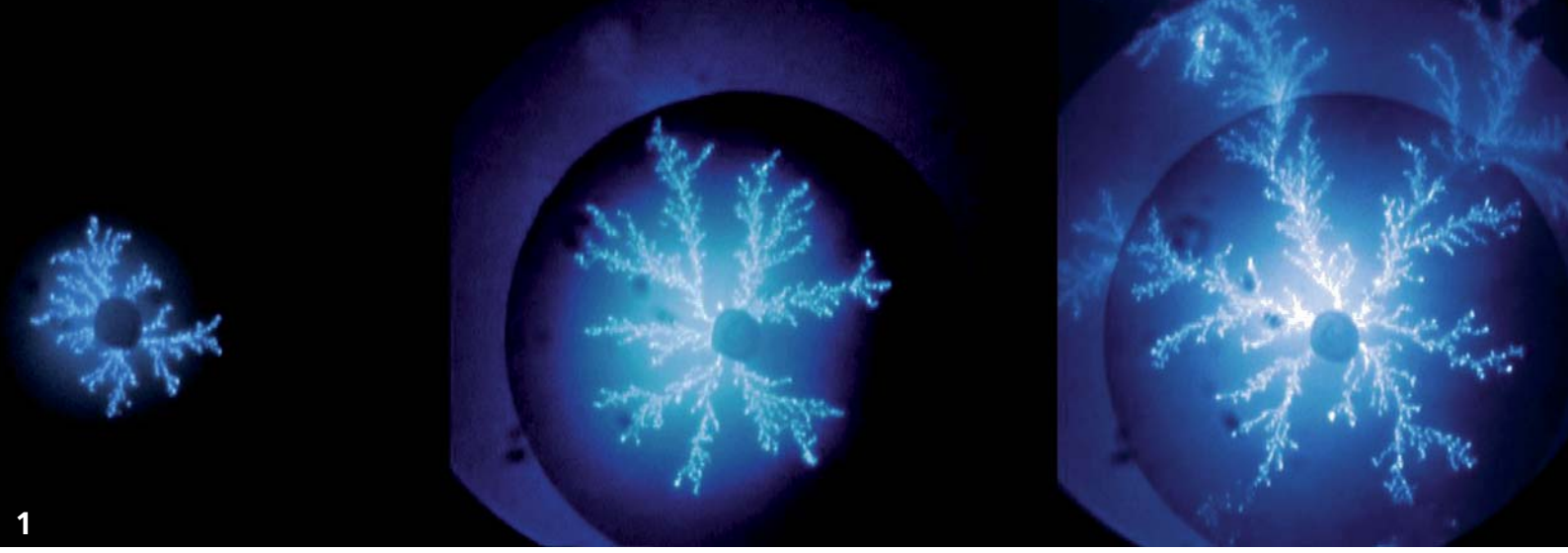

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COATING DESIGN WITH HIGHLY ACTIVATED METAL PLASMA

THE TASK

The technical realization of transparent electrodes is a key issue for the development of future technologies in solar applications, for the development of optoelectronic devices and for display technologies. Today's electrodes are primarily made from selected transparent conductive oxides (TCO). However, the electrical conductivity of these materials is relatively low, their mechanical properties are for many applications less favorable and the manufacturing processes are relatively costly.

Fundamental innovation in this area could offer new momentum for many high-tech applications. Alternative coating materials are for example very thin metal films. The achievable conductivities are 100 – 1000 times higher than those of TCO materials. Subsequently the coatings can be made much thinner and thus transparent.

Conventional thin film coating technologies such as evaporation and sputtering typically lead to island type growth kinetics. A minimal film thickness (percolation threshold) has to be deposited to interconnect the islands and get a conductive film. For most materials this occurs for thicknesses beyond 10 nm, which reduces the transparency of the films so that they are not useful as transparent electrodes.

OUR SOLUTION

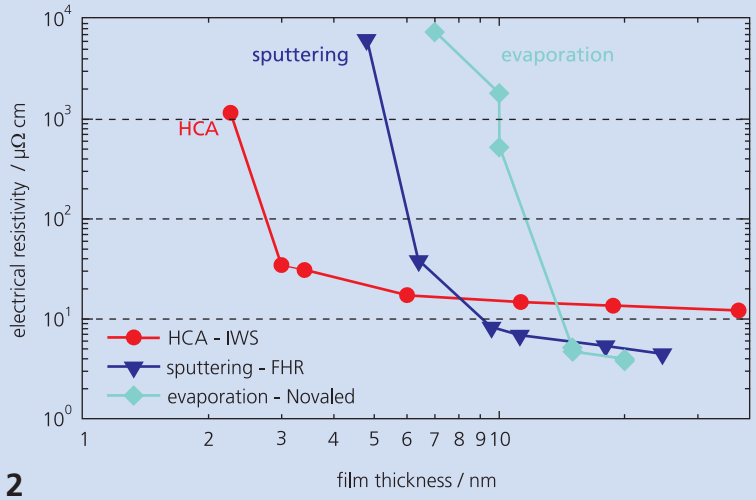
Fraunhofer IWS engineers develop a pulsed high current arc process (**H**igh **C**urrent pulsed **A**rc – HCA) that generates metal plasmas with extremely high ionization degrees and ion energies. Coatings produced with this process do not start the film growth in the form of islands. Rather the incoming ions are subplanted into the substrate surface. This leads to extremely dense and uniform structures. Due to the pulsed mode of operation the HCA technology offers a high flexibility with respect to the adjustable process parameters, which makes it an ideal tool to optimize coating conditions.

The HCA technology was deployed to deposit silver onto glass substrates. Transparency and electrical conductivity were measured. The coatings were also compared to those made by project partners with evaporation and sputtering processes.

RESULTS

The diagram shows results of the electrical resistivity measurements as a function of the silver film thickness.

Conductivity of thin silver films, which were deposited using different coating processes



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Clearly visible are the different percolation thresholds for the electrical conductivity and various coating processes. The films deposited by evaporation show a significant resistivity drop for thicknesses beyond 10 nm. Sputtering shows the effect between 5 - 6 nm. The HCA technology achieves the increase in conductivity already at thicknesses between 2 - 3 nm. The HCA coated silver films are sufficiently transparent and conductive for many applications. Current research projects focus on the further optimization and development to commercialize these coatings as an additional alternative to know TCO materials.

1 High current arc discharges of different pulse lengths on a metal cathode. The cathode spots of the discharge, which are eroding an increasingly larger area with increasing pulse length are visible (in the picture from left to right). High current arc discharges in the kilo ampere range generate highly ionized plasmas with multiply charged ions.

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