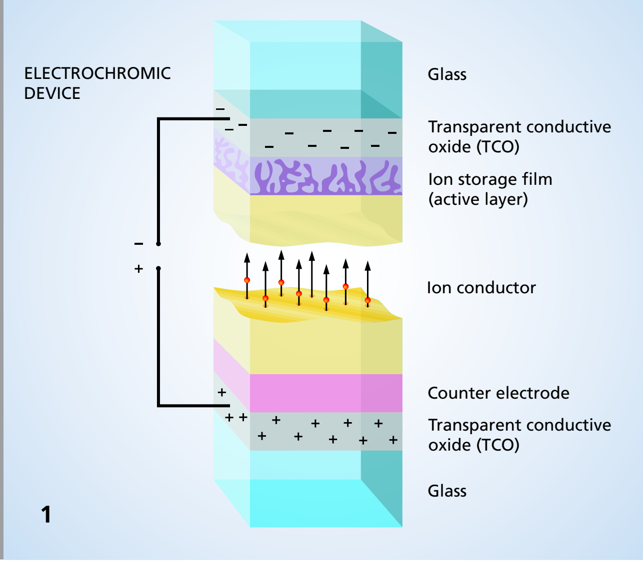

NEW MATERIALS FOR SWITCHABLE GLAZING

The demand for switchable glazing that regulates light transmission and the transmission of energy is increasing for reasons associated with comfort and rising energy costs. This demand primarily involves the glazing for buildings and automotive glazing for the roofs of automobiles. The electrochromic coatings needed for these types of systems are being developed at the Fraunhofer IST.

The principle

The principle structure of an electrochromic film system is shown in Fig. 1. It essentially corresponds to the principle structure of a lithium-ion battery, however with transparent electrodes and an active coating, as well as counter-electrode materials that change their light transmission properties depending on the charge state. As a rule, the active coating consists of tungsten oxide (WO_3). Lithium is stored in this coating when a negative voltage is applied. It then turns dark. This process is referred to as cathodic switching behavior. By switching the polarity of the voltage, the lithium from the active coating is transferred to the counter-electrode via the electrolyte and stored there. This brightens up the active coating.

Ideally, the counter-electrode shows an opposite anodic switching behavior, i. e. a brightening at lithium storage and a darkening in the status without lithium. Such an anodic switching behavior is known for only a few oxides of the transition metals, examples are chromium (Cr), cobalt (Co), manganese (Mn), nickel (Ni), vanadium (V), iridium (Ir), iron (Fe), and ruthenium (Ru). In this regard iridium and ruthenium are not considered for large-surface use for financial reasons. Thus iridium oxide (IrO_2) is only used on small surfaces in switchable auto mirrors. Other boundary conditions that must be considered for use are the achievable light/dark switch states, cycle stability, color impression and the health aspects of the materials.

Innovating counter-electrodes

Currently at the Fraunhofer IST, as part of the joint project "Smart Windows of the 2nd Generation 'ECWin2.0'" with the grant number 13N13375 a new generation of counter-electrodes is being developed jointly with project partners EControl-Glas GmbH & Co and GFE Fremat GmbH. The objective is to modify the existing counter-electrode – a metal1-metal2 oxide – provided from the project partner EControl by adding the elements cited above, and thus in particular further improve the switching behavior and the current slightly yellow color impression.

To do this at the Fraunhofer IST new mixed oxides are being produced via reactive co-sputtering of up to three sputtering sources. The lithium absorption capacity is evaluated by means of cyclic voltammetry. In parallel the visual transmission and its change are measured. After the initial orienting depositions of the pure oxides, e. g. metal1-oxide (see Fig. 2) a wide variety of mixtures were realized. In this regard the most successful shows the desired anodic switch behavior over areas. The optical density (OD) decreases at lithium incorporation (see the opposite graph, $\Delta OD < 0$), i. e. the coating brightens up. The coatings show a concurrent capacity to adequately absorb lithium.

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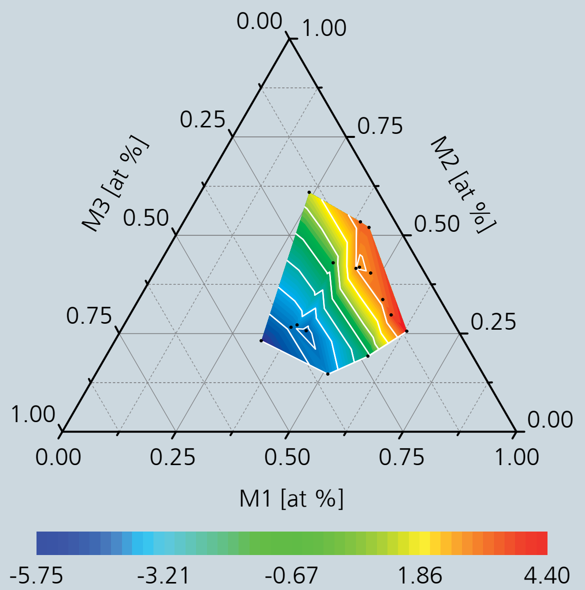
Outlook

Currently the most successful mixed oxides are being investigated relative to their cycling stability and in the composite with the active coating. Moreover, tests on a larger surface in a pilot scale of 30 x 40 cm^2 are planned.

Change in the optical density (ΔOD) depending on the composition of the metallic components of the counter-electrode.



1 *The principle structure of an electrochromic film system.*

2 *Counter-electrode of metal1-oxide on glass with transparent electrode.*

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