Towards Neutral Color Electrochromic Devices based on Flexible Substrates

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In respect of their adaptability and performance, electrochromic devices, ECDs, which are able to change their optical properties under an applied voltage, have received significant attention. Target applications are multifold, such as automotive sunroofs, smart windows, ophthalmic lenses, and domestic appliances (oven, fridge…). Despite intense studies, rapid commercialization still suffers from limitations such as insufficient durability, non-neutral colors, limited mechanical flexibility, and long response time. Aiming at building large scale ECDs based on flexible substrates, several issues are addressed in the framework of the European project INNOSHADE. In this paper, in particular improvements in full EC devices will be discussed, focusing on the study of two layers, namely the counter electrode and the transparent electrode.

The switching speed of large scale ECDs is still largely limited by the transparent conducting oxide, TCO, layer. Due to its abundancy, low cost and non-toxicity, ZnO has been identified as a key candidate to replace the state-of-the-art material ITO (i.e. In_2O_3:Sn) or the commonly used FTO (i.e. SnO_2:F). Improvement of the electrical and optical properties of ZnO thin films is achieved by doping. Particular attention is paid to the deposition at low substrate temperature ($T < 150$ °C) using, as an initial step, the Pulsed Laser Deposition, PLD, technique. Enhancement of the electrical properties is achieved by Si doping, resulting in SZO (ZnO:Si) thin films exhibiting a resistivity as low as 7 E^{-4} Ωcm [1]. In addition to a detailed study of the influence of the Si composition on the TCO properties of PLD deposited ZnO thin films, recent development towards larger scale deposition by sputtering techniques will be presented.

With respect to find suitable counter electrodes for neutral tint plastic based devices, the performance of NiO thin films was successfully improved by various approaches, in particular by the preparation of Ni^{3+} containing films. Various synthesis routes (PLD, sol gel) will be compared in terms of cycling stability in lithium conductive ionic liquid. Finally, the performance of full devices, comprising WO_3 or PEDOT layers as working electrodes and NiO as the counter electrode will be reported.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7) under grant agreement n° 200431 (INNOSHADE).

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