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Anthony Maho. Plasmonic nanostructures of indium-tin oxide ITO and substoichiometric tungsten oxide WO<sub>3-x</sub> as innovative electrochromic materials for highly-selective dual-band VIS-NIR smart windows. FEMS EUROMAT 2023 - International Congress for the latest advancements in Materials Science and Technology, German Society for Materials Science - DGM, Sep 2023, Franckfurt, Germany. hal-04585493

**HAL Id: hal-04585493**

**<https://hal.science/hal-04585493>**

Submitted on 23 May 2024

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# Plasmonic nanostructures of indium-tin oxide ITO and substoichiometric tungsten oxide $WO_{3-x}$ as innovative electrochromic materials for highly-selective dual-band VIS-NIR smart windows

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Nanostructures of selected highly doped metal oxides feature a strong optical absorption behaviour due to localized surface plasmon resonance (LSPR), which can be tuned all across the solar spectrum through careful material selection and synthetic design (size, shape, doping). The plasmonic response can also be changed post-synthesis by the application of an appropriate electrical bias for the variation of the charge carrier concentration, which ultimately allows the dynamic modulation of the LSPR intensity and spectral position between visible (VIS) and near-infrared (NIR) ranges. Such optical selectivity is particularly praised in many applications related to smart energy materials and devices, including advanced electrochromic windows with abilities of selective modulation of both light and heat fluxes, for which these plasmonic nanostructures have shown additional benefits in terms of extremely fast switching kinetics as well as high optical contrasts, coloration efficiency, and cycling durability. As two benchmark materials in that context, tin-doped indium oxide (ITO) typically presents a NIR modulation ability around 1500-2000 nm, and oxygen vacancy-doped tungsten oxide ( $WO_{3-x}$ ) testifies for a dual-band VIS-NIR response around 600-1200 nm.

This contribution will review the state-of-the-art of these plasmonic electrochromic materials as original and cutting-edge components of “new-generation smart windows”, while highlighting the latest research contributions under progress and/or recently achieved in this context [1-5] by University of Bordeaux / ICMCB-CNRS (in collaboration with Dr. Aline Rougier), University of Liège – GREEnMat (Prof. Rudi Cloots), University of Texas in Austin (Prof. Delia J. Milliron) and Imperial College London (Prof. Sandrine Heutz). Plasmonic nanostructures of ITO and  $WO_{3-x}$  are typically obtained from colloidal syntheses (thermal decomposition under Schlenk line, hydrothermal processes) and deposited into thin films from spin or spray coating wet approaches. Obtained layers are then characterized in terms of morphology (STEM, AFM), structure (XRD), optoelectronic properties (UV-VIS-NIR spectrometry, EPR) and electrochemical response (cyclic voltammetry, chronoamperometry, impedance spectroscopy); noteworthy, electrochemical measurements are achieved *in operando* by being coupled with UV-VIS-NIR spectrometry so to assess the electrochromic functionality and efficiency of the processed materials.

## References

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