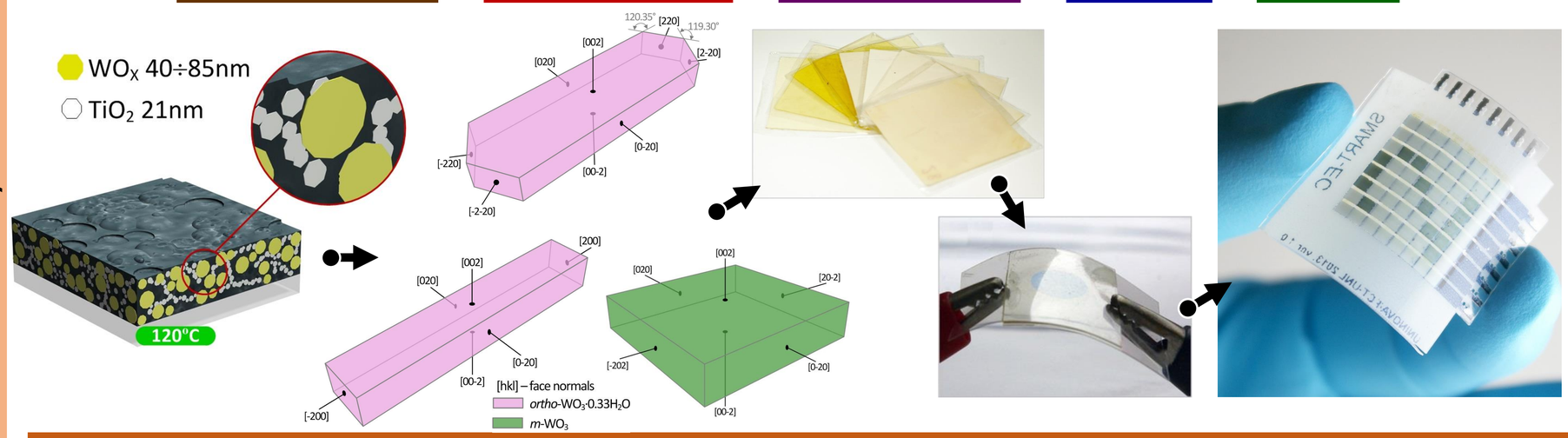
Printable organic and inorganic materials for flexible electrochromic devices

EC films with controlled microstructure → **EC films with controlled nanostructure** → **All-solid-state structure** (solid electrolyte) → **Flexible devices** → **Fully printed devices**



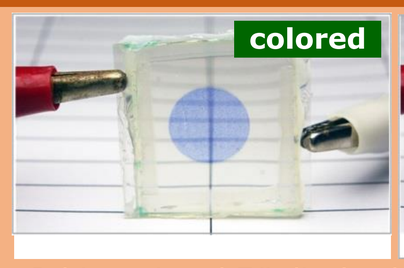
Pawel Jerzy Wojcikk
Post-Doc

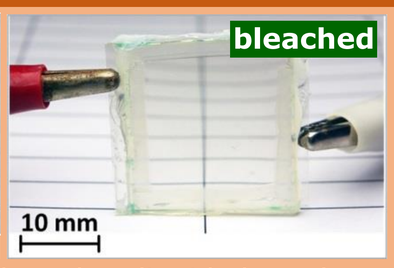
Supervisors: Prof. Elvira Fortunato
Prof. Rodrigo Martins

Objectives

The goal was to develop materials and processes alternative to existing aiming at:

compatibility with flexible substrates ->	low temperature processing and environmental stability
low cost ->	fully printed devices in a roll-to-roll process
high performance ->	all-solid-state structure
power efficiency ->	reflection mode and optical memory
eco-friendly ->	water based or solvent free inks/pastes
widely available solutions ->	easily accessible components

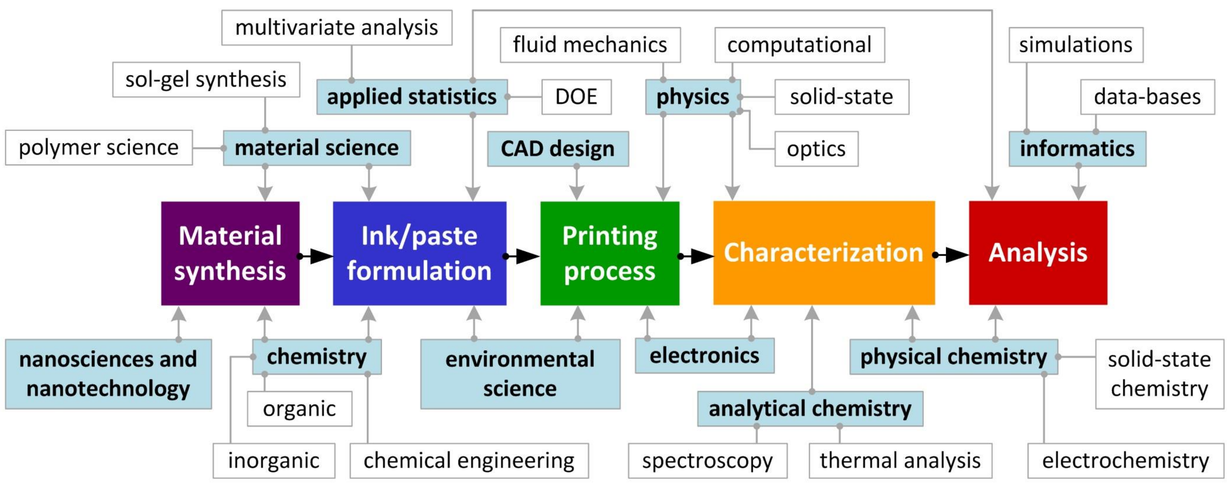


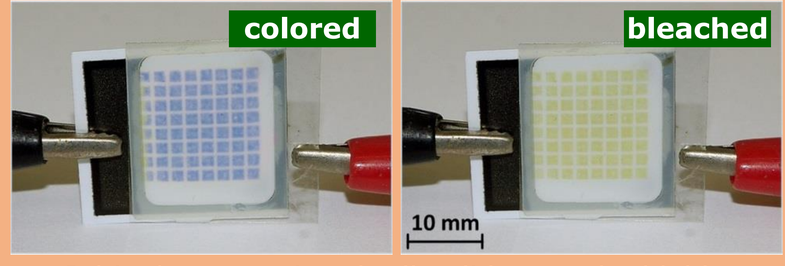


Inkjet printed EC display based on liquid electrolyte

Inkjet printed, all-solid-state, beddable, large area EC window

Methods and techniques





Inkjet/screen printed, all-solid-state, beddable EC paper display

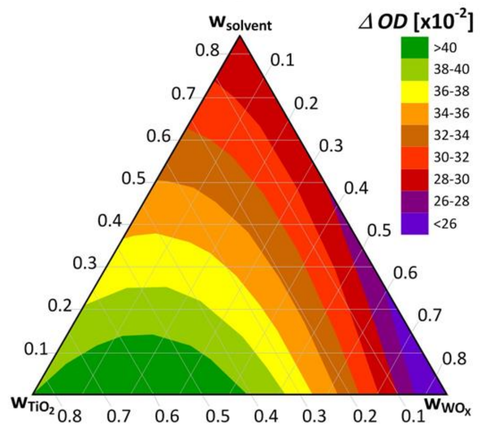
Paper EC display integrated with printed backplane

Results

Electrochromic performance of printed tungsten oxide (WO_3) films:

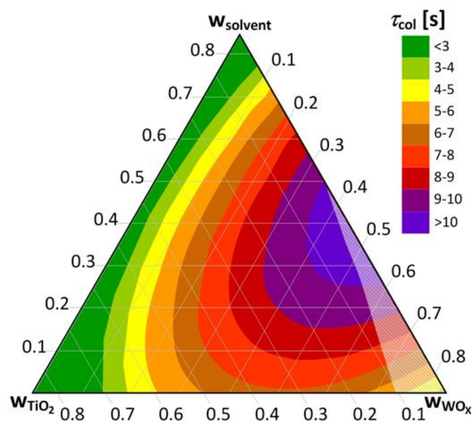
Change in optical density

$$\Delta OD = ln\left(\frac{T(t_1,\lambda)}{T(t_2,\lambda)}\right)$$ ← Bleaching ← Coloration

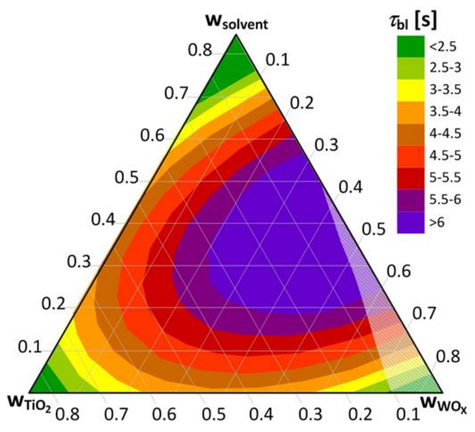


Switching dynamics

coloration time



bleaching time



Publications

1. Wojcik, P.J., Cruz, A.S., Santos, L., Pereira, L., Martins, R., Fortunato, E.: Microstructure control of dual-phase inkjet-printed *a*-WO_3/TiO_2/WO_X films for high-performance electrochromic applications. *Journal of Materials Chemistry*. 22, 13268 (2012).
2. Wojcik, P.J., Pereira, L., Martins, R., Fortunato, E.: Statistical mixture design and multivariate analysis of inkjet printed *a*-WO_3/TiO_2/WO_X electrochromic films. *ACS Comb. Sci.* 16 (1) 5-16 (2014).
3. Wojcik, P.J., Pereira, L., Martins, R., Fortunato, E.: Metal Oxide Nanoparticle Engineering for Printed Electrochemical Applications. In: Nano-Electrochemistry: Electrochemical Synthesis Methods, Properties and Characterization Techniques. Handbook of Springer – under edition.

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