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Supplementary Information

Controlling the Electrochromic Properties of Conductive Polymers Using UV Light

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Short recapitulation of the previous report

In the previous work '*Patterning and conductivity modulation of conductive polymers by UV light exposure*' we demonstrated a novel technique to pattern the conductive polymer PEDOT:Tos produced by VPP. By exposing the oxidant solution to UV-light through a photomask prior to polymerization the conductivity of the resulting CP film was able to be modified by over 6 orders of magnitude in addition to selectively removing parts of the film.

The patterning mechanism and the resulting CP films were also explored in the previous report. We hypothesized that the UV-light changes Fe(III) coordination shell in the oxidant solution leading to faster polymerization kinetics. This faster kinetics results in the synthesis of short polymer chains with different electronic structure and morphology compared to the PEDOT produced without the UV-light exposure step. These changes were shown to affect both the electrical and optical properties of the CP. The FT-IR analysis revealed a reduction in the concentration of charge carriers, while a transition from bipolarons to polarons was observed in the UV-VIS spectra. Additionally, the UV-VIS indicated a shortening of the conjugation length and/or the CP chain length.

Dissolving of the PEDOT films after the oxidant exposure to UV light (unless annealed post polymerization) was another interesting observation reported. Therefore patterns could be created where exposed regions were dissolved and the sole areas of high conductive PEDOT being preserved.

However, post polymerization annealing allowed both the low conductive PEDOT and the high conductive PEDOT to remain, thus producing 'electrical patterns'.

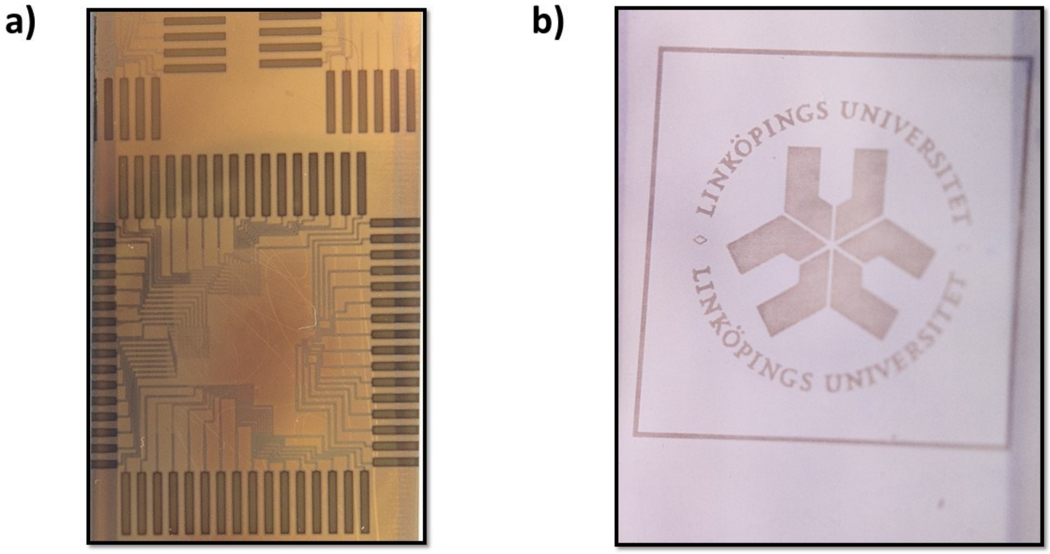

Figure SI1. Advanced patterning of PPy by UV-light exposure of the oxidant solution. a) circuit example and b) logo example.

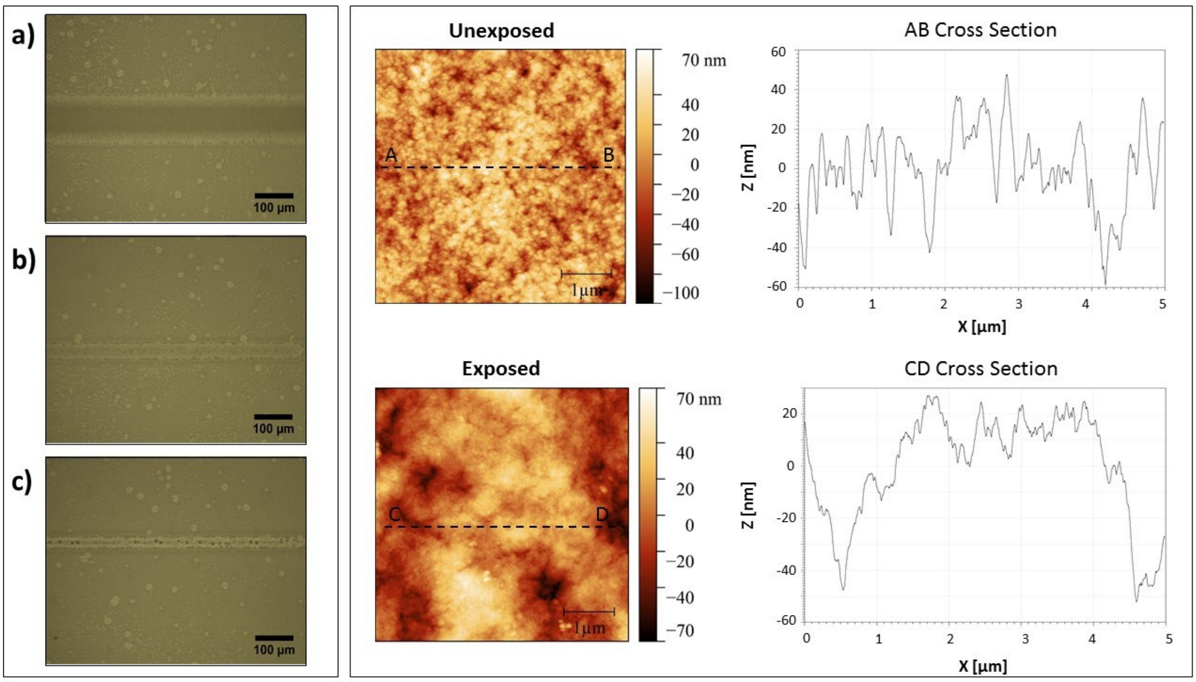

Figure SI2: Patterns of PPy with regions of high-conductivity CP (25.6 S/cm) and low-conductivity CP (0.01 S/cm). Images show patterns' resolution of a) 100 µm, b) 20 µm and c) 10 µm, together with AFM morphology images and cross sections of exposed (600 seconds) and non-exposed regions.

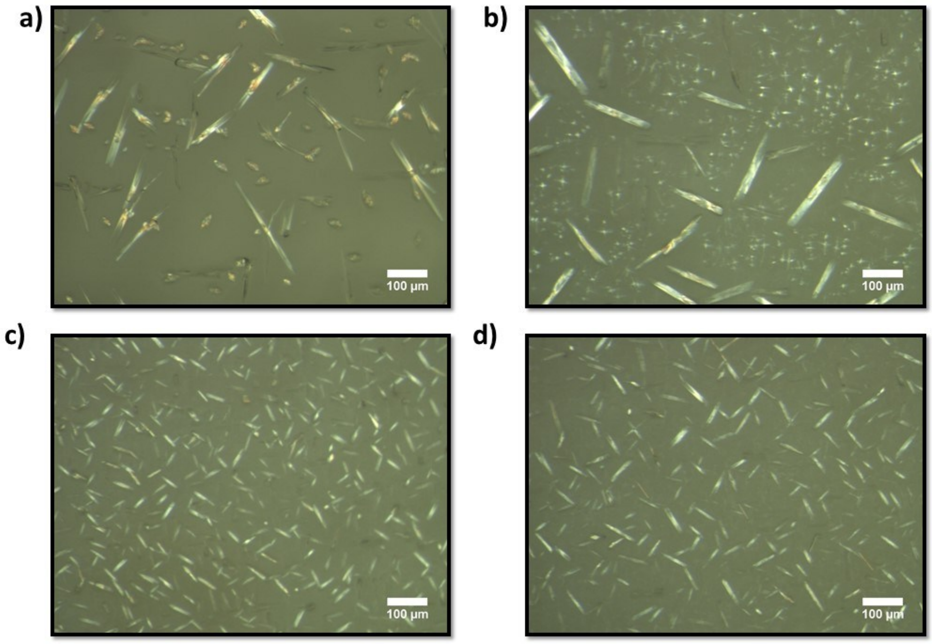

Figure SI3. Microscope images of the oxidant exposed to UV light for various times and then kept for 12 hours in atmospheric conditions before PPy production via VPP. a) 0 s, b) 300 s, c) 600 s and d) 900 s.

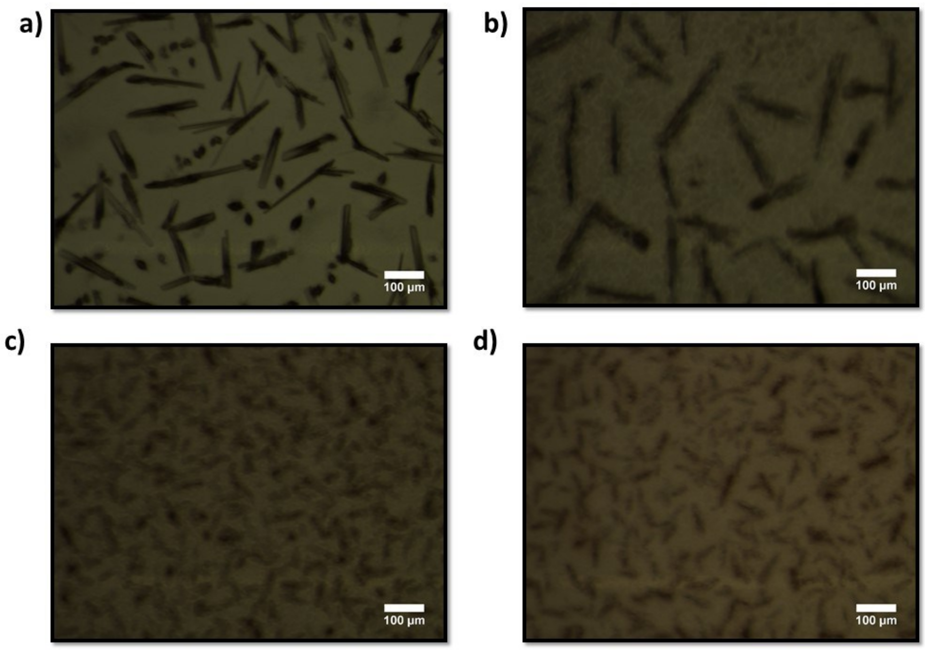

Figure SI4. Microscope images of PPy thin films after the oxidant was exposed to UV light for various times and left for 12 hours. a) 0 s, b) 300 s, c) 600 s and d) 900 s.

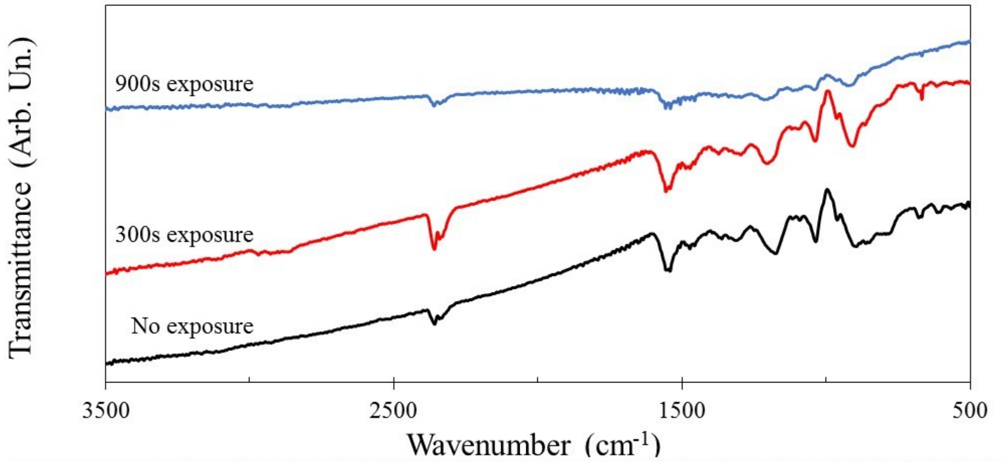

Figure SI5. FTIR spectra of PPy thin film where the oxidant solutions were exposed to UV-light for various times before VPP of pyrrole was performed.

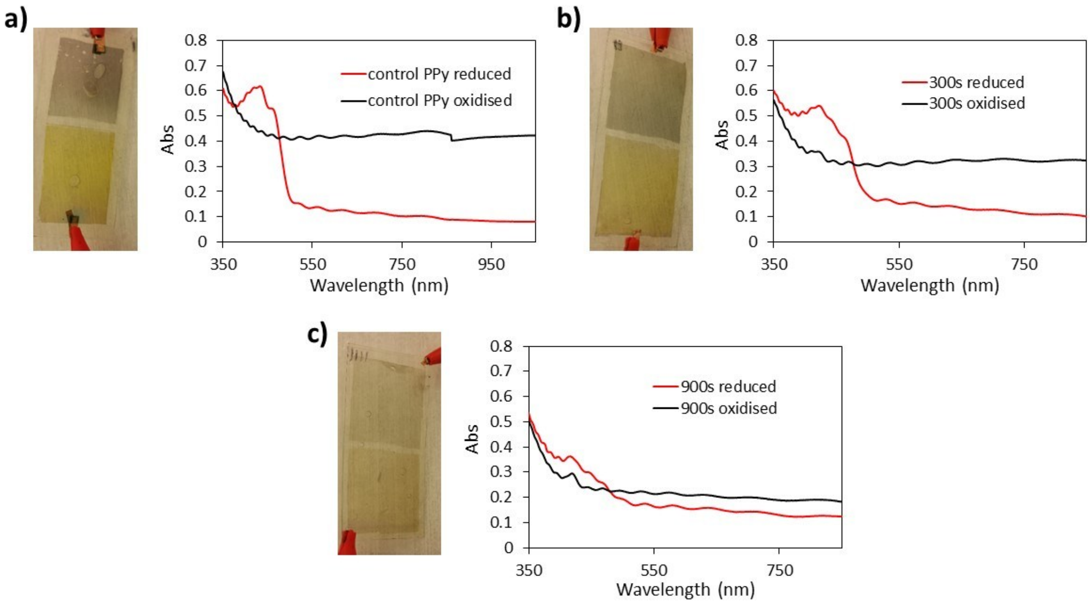

Figure SI6. Electrochromic behavior of PPy thin films in lateral devices, images and UV-VIS spectra are included to show the contrast between the two states of the various exposure times. a) 0 s, b) 300 s and c) 900 s

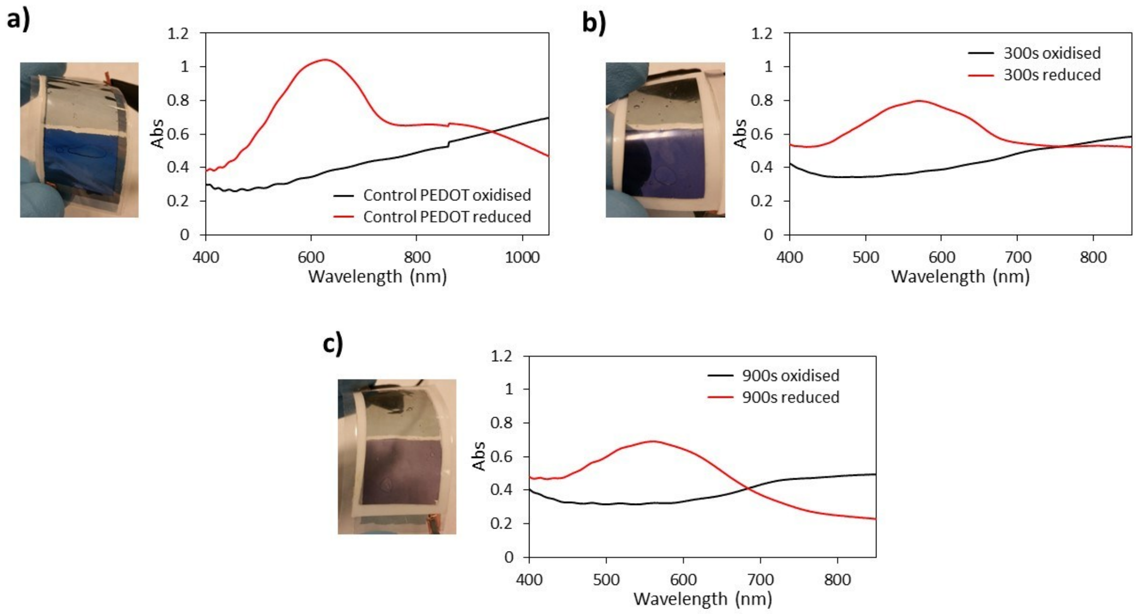

Figure SI7. Electrochromic behavior of PEDOT thin films in lateral devices, images and UV-VIS spectra are included to show the contrast between the two states of the various exposure times. a) 0 s, b) 300 s and c) 900 s

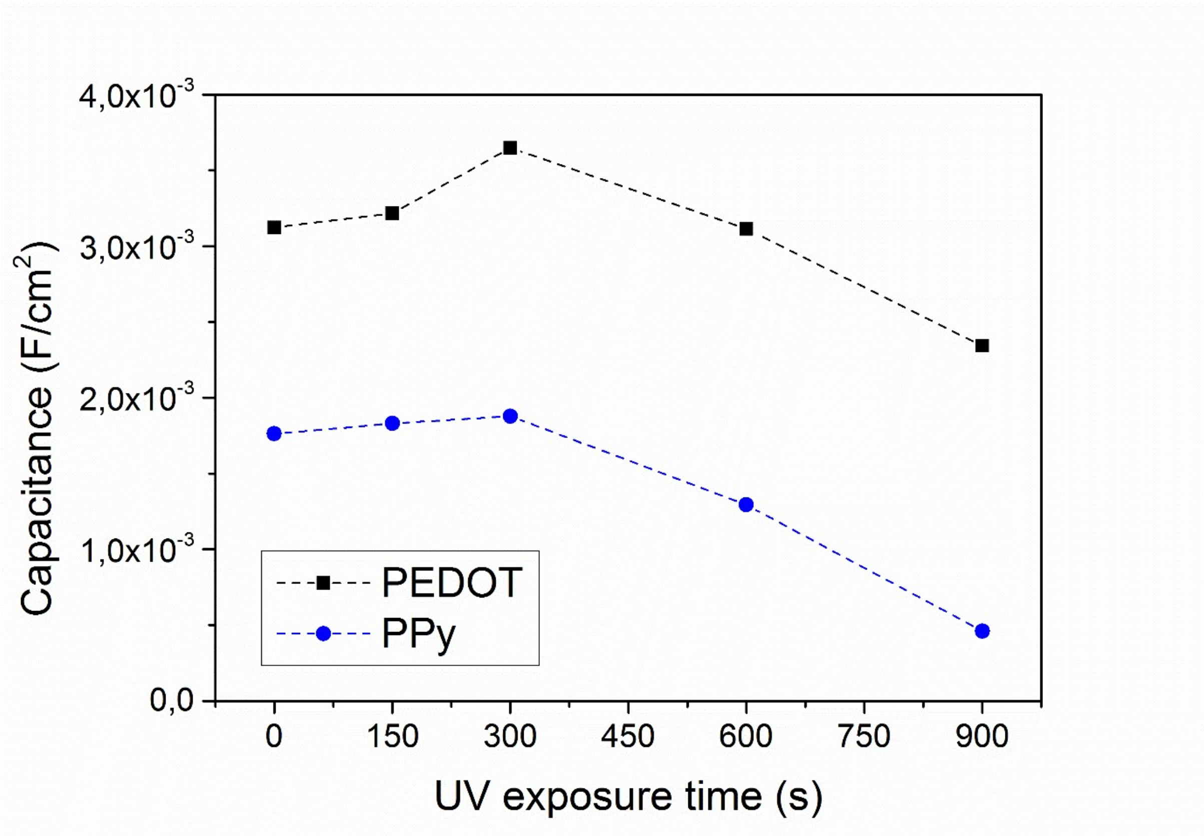

Figure SI8. Capacitance of CP films exposed to UV light for different time intervals.

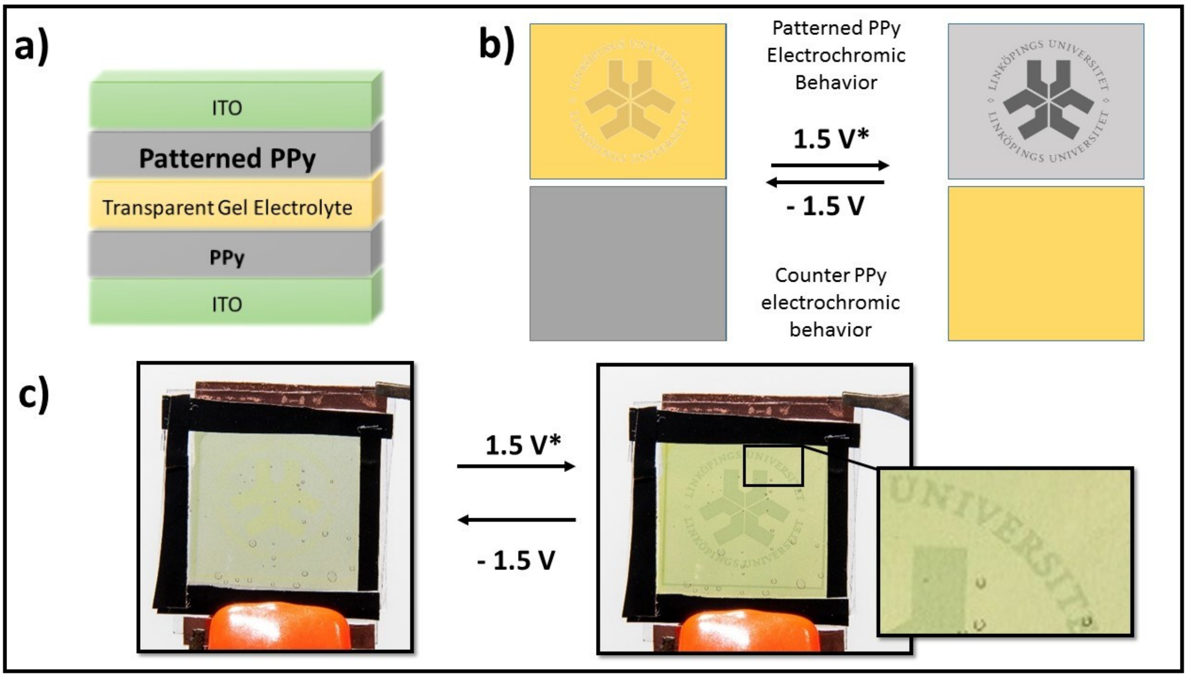

Figure SI9. a) Electrochromic device design incorporating a UV-light patterned PPy layer with PPy as the counter polymer with a transparent gel electrolyte. b) Individual electrochromic behavior of the two patterned CPs when under applied voltages of +1.5 V and -1.5 V. The images appear and disappear in opposites allowing a double image device. c) The PPy device in both states is presented with the pattern becoming visible when the patterned PPy layer is oxidized and disappears when reduced. Voltages stated are applied to the patterned CPs.

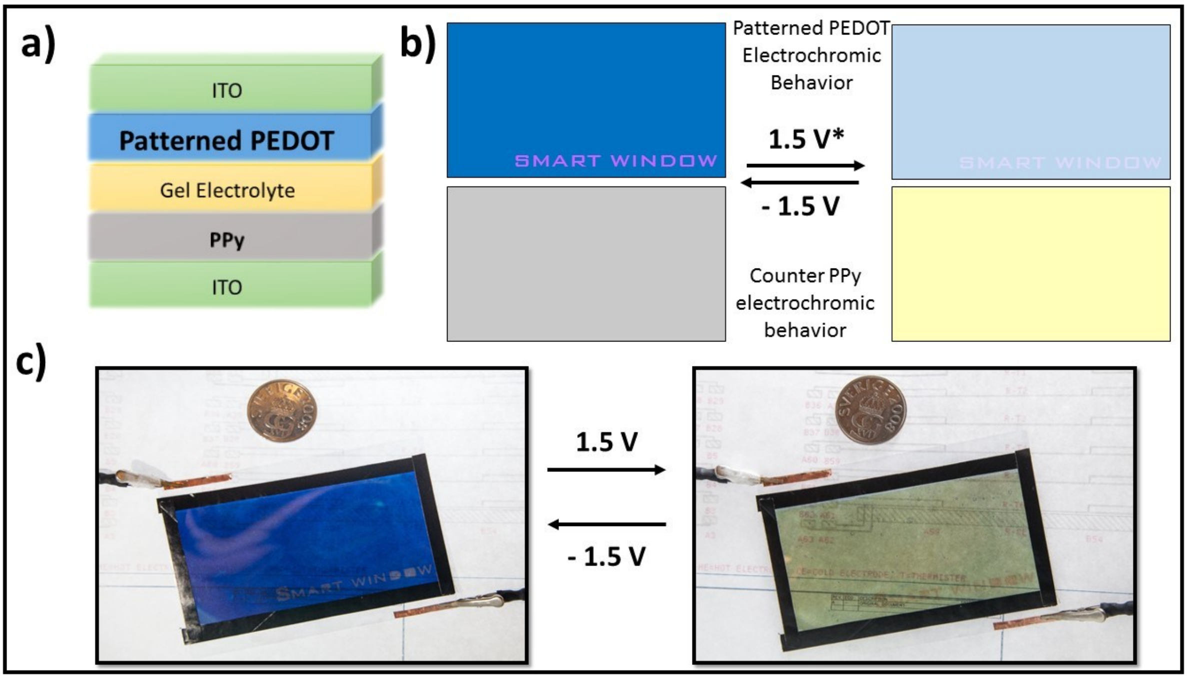

Figure SI10. Prototype electrochromic devices incorporating patterned PEDOT and PPy counter polymer. a) device architecture b) individual electrochromic behavor of the two CP layers when under applied voltages of +1.5 V and -1.5 V and c) The 'watermarked' smart window prototype in both states. *Voltages are applied to patterned PEDOT.

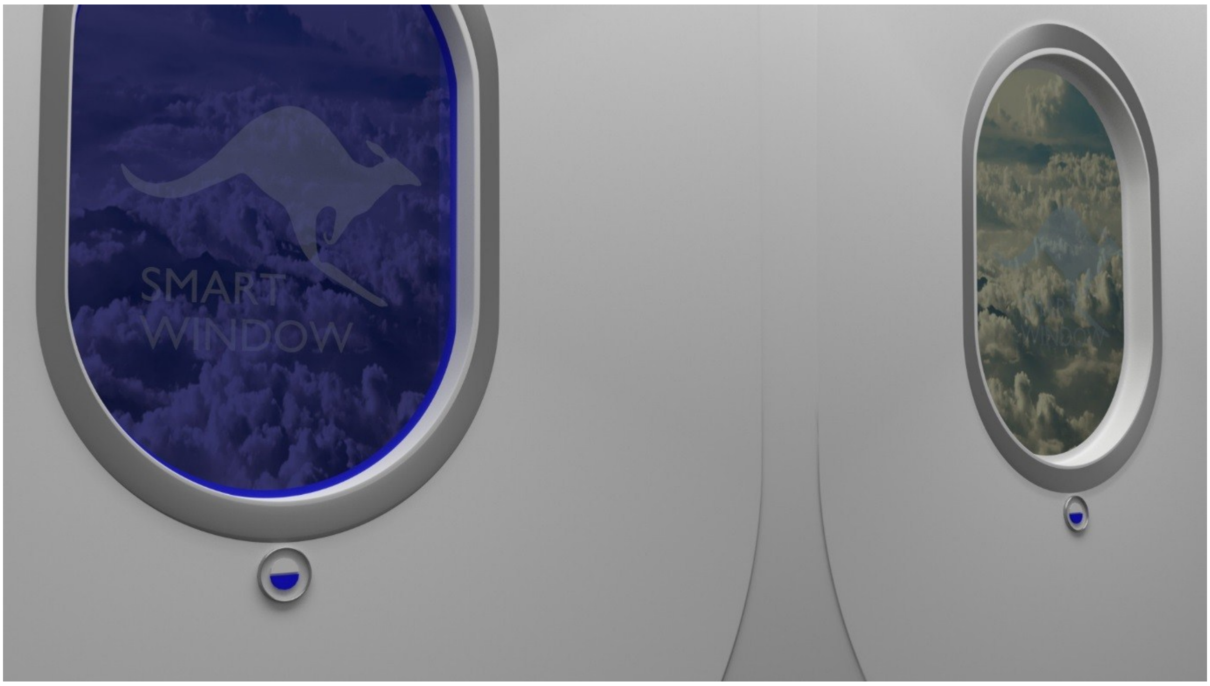

Figure SI11. Conceptual application of company advertisement within airplane electrochromic windows. Artist: Robert Brooke.