Ultrasonic spray deposition of mesoporous WO_3 films displaying 100% optical modulation

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"Smart windows" consist of glass with a thin film electrochromic device. The transparency of the smart window may be switched between opaque and transparent state by applying a small voltage through the structures, mitigating the solar heat gain/lighting and greatly diminish the energy usage in commercial buildings. The widespread of smart window is constrained by the need for scalable, low cost manufacturing. We are evaluating the use of ultrasonic spray deposition (USD) as a green manufacturing approach for large scale production of smart window. USD is an in-line deposition technique operated under ambient pressure which can be applied to all the layers in an electrochromic device. Moreover, we are using this approach to create nanocomposite structures that promote efficient ion transport.

This presentation is mainly focus on demonstrating a novel approach to fabricate tungsten oxide thin films, the primary electrochromic layer. We successfully synthesized mesoporous tungsten oxide thin films by adapting template assisted sol-gel chemistry into USD process. One tri-block copolymer was added into anhydrous ethanol and formed a micelle structure. Tungsten chloride was then added, which formed tungsten alkoxide complexes. Then the complexes were adsorbed on the surface of the micelles. This solution was ultrasonically sprayed on transparent conducting oxide coated glass substrates at room temperature to form gel–like films. The substrates were then placed in a humidity controlled atmosphere to carry out hydrolysis reactions and convert tungsten alkoxide into tungsten hydroxide. Through an annealing process, tri-block copolymer was removed and formed mesoporous structure of tungsten oxide films. The electrochromic performance of the tungsten oxide films was characterized by performing step potential change experiment in direct registry with measurements of optical transmission as shown in Figure 1. The best optical modulation (100%) of tungsten oxide films in the history is obtained. The excellent performance is attributed to the mesoporous structure deposited by USD that enhances ion transport. In this presentation we will discuss the electrochromic performance as well as the characterization of the resulting films.

We have also developed USD for synthesis of nanocomposite films used for the ion storage layer and the solid state electrolyte. The former is a $NiO/LiNO_3$ composite produced by spray pyrolysis. The latter is a composite polymer electrolyte comprised of silica nanoparticles dispersed in a polymethylmethacrylate matrix. We have combined these processes to build the first solid state electrochromic devices by USD. In addition to studies of the intrinsic WO_3 layer, we will also describe the performance of complete devices.

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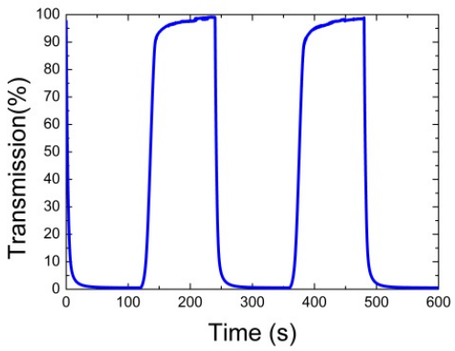

Figure 1 dynamic optical response to applied step potentials from a film deposited using 2C x 2 passes.