Electrochromic properties of dandelion flower like nickel oxide thin films

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Fabrication of DFL-NiO based electrochromic Devices

The EC device configuration for DFL-NiO thin film was Glass/ITO/NiO/KOH/ITO/Glass. NiO thin films deposited on ITO coated conducting glass substrate acts as a working electrode and ITO coated conducting glass substrate acts as counter electrode were assembled together with double sided tesco tape of 1.5 mm thickness to produce a sandwich-type electrochromic device. The liquid electrolyte (1M KOH) was filled into the device through a small hole and sealed it with resibond epoxy glue. The EC device was dried in air for 1 day before studying EC performance.

Characterization

The structural properties of the DFL-NiO thin films were studied from X-ray diffractometer (Regaku Miniflex Model No.600) Cu K_α radiation (λ=1.54 Å). The fourier transform infrared (FT-IR) spectrum of powder collected from NiO samples were recorded using Perkin-Elmer IR spectrophotometer (model-100) in the spectral range 400–4000cm^{-1}. The pellets were prepared by mixing KBr with NiO powder collected by scratching film from glass substrates, in the ratio of 300:1 and then pressing the powder between two pieces of polished steel. The surface morphologies of the DFL-NiO thin films thus produced were characterized by scanning electron microscopy (SEM, JEOL-JSM-6360, Japan). The elemental and structural information of the NiO thin films were analyzed using x-ray photoelectron spectrometer (XPS,

VG Multilab 2000-Thermo Scientific Inc. UK, K_α) with a microfocus monochromated Al Kα X-ray working with high photonic energies from 0.1 to 3 KeV. All the electrochromic measurements were performed in an electrolyte of 1 M KOH in a conventional three-electrode arrangement comprising NiO thin film as a working electrode, platinum wire as the counter electrode and saturated calomel electrode (SCE) served as the reference electrode using an electrochemical analyzer (model-CHI-400A) by CH Instrument, USA. In-situ transmittance was recorded using a He-Ne Laser (λ=632.8 nm), a Si photodiode and a storage oscilloscope. The optical transmission and colorimetric analysis were done with the help UV–Vis spectrophotometer (Shimadzu, model: UV-1800, Japan) in the wavelength range of 300–1100 nm and Shimadzu made color analysis software equipped UV–Vis spectrophotometer by analyzing transmittance spectra of color/bleach state to evaluate L*a*b* and Yxy coordinate values.

Growth Mechanism of DFL-NiO

The DFL-NiO thin films composed of nano-flakes were probably grown by nucleation and growth from small nanocrystals containing divalent metal cations of Ni and O-octahedra. The oxygen octahedra formed of six hydroxyl groups and centered Ni^{2+} cations share their edges to form two-dimensional (2D) sheets of $Ni(OH)_2$, which were formed of even smaller nanocrystals via various interlayer chemical interactions. The ammonia intromitted in the reaction not only acts as the complex agent but also plays a key role in the formation of $Ni(OH)_2$ nanosheets making them very flexible.[1] The possible reaction mechanism formulated is as follows:[2]

$$NiSO_4 \cdot 6H_2O + 2NH_3 + K_2S_2O_8 \leftrightarrow Ni(NH_3)_6{}^{2+} + S_2O_8{}^{2-} + K_2SO_4$$

$$Ni(NH_3)_6{}^{2+} + S_2O_8{}^{2-} \leftrightarrow Ni^{2+} + S_2O_8{}^{2-} + 6NH_3$$

$$Ni^{2+} + 2OH^- \leftrightarrow Ni(OH)_2$$

$$2Ni(OH)_2 + S_2O_8{}^{2-} \leftrightarrow 2NiO(OH) + 2SO_4{}^{2-} + 2H^+$$

After annealing at 300 ^oC for 90 min, the mixed phase of $Ni(OH)_2$/NiOOH converts into DFL-NiO composed of nano-flakes.

Fourier Transform infrared (FT-IR) Spectroscopic Studies

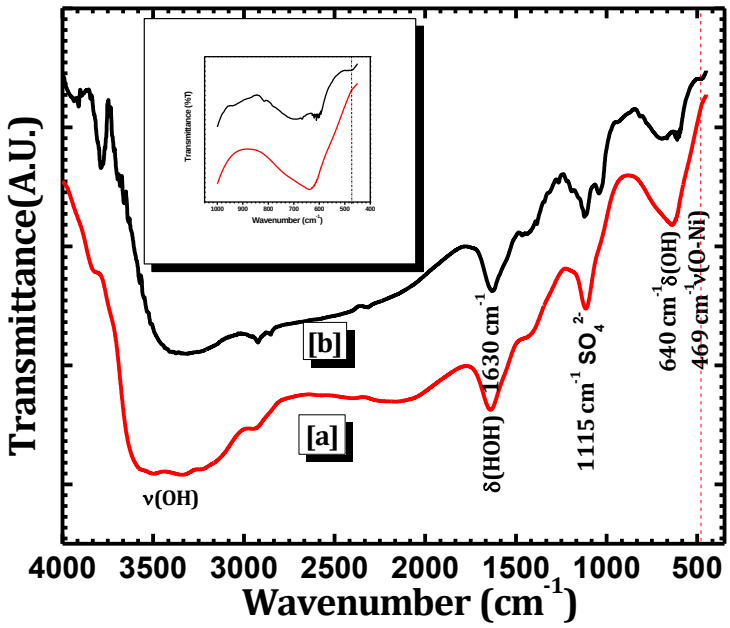

Fig.S1 FT-IR spectra of (a) as prepared and (b) annealed NiO samples scratched from thin films.

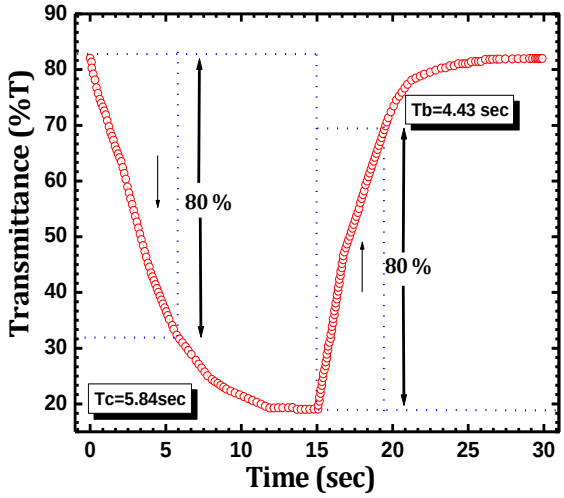

Fig.S2 In-situ transmittance response curve during the first pulse potential cycling of DFL-NiO thin film.

References:

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2. X. H. Xia, J. P. Tu, J. Zhang, X. L. Wang, W. K. Zhang and H. Huang, *Sol. Energy. Mater. Sol. Cells.*, 2008, **92**, 628.