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Design and Development of Electro chromic Device using WO3 and Evaluation of its Optical and Thermal Properties

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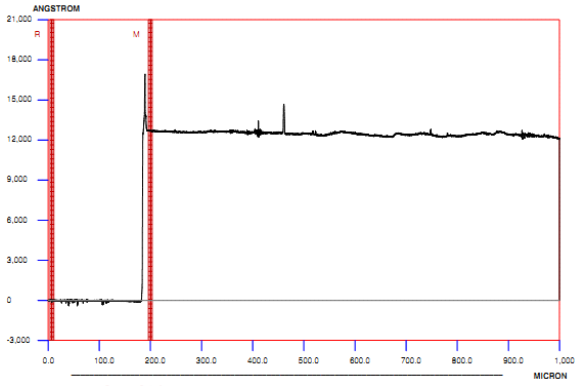
Abstracts—Electrochromics(EC) is a healthy blend of basic physics and chemistry, thin film science, device technology and market opportunities. Use of electrochromic materials as smart windows in an interactive architecture of buildings provide a better option for energy saving. Device is fabricated using WO3 ,thin film under laboratory conditions and tested for optical and thermal properties to evaluate energy saving.

I. PREPARATIONS

Dissolution of 3.74 g of tungsten metal powder in a mixture of 40 ml of 30% H2O2 and 4 ml of deionizer water yielded a colorless solution of peroxotungstic acid. The reaction being exothermic was conducted between 0 and 10 °C. The clear solution obtained upon filtration was refluxed at 55 °C for 1 h. mixing equal volumes of this solution with anhydrous absolute ethanol and water yielded the deep yellow-colored deposition sol, which was warmed at 50 °C before use. The sol remains stable for at the most 10 days when preserved at temperatures below 10 °C. The films were deposited under potentiostatic conditions in a three-electrode electrochemical cell with a platinum sheet as the auxiliary electrode, a ITO coated glass substrate as the working electrode and saturated calomel electrode (SCE) being the reference electrode. The working electrode was subjected to a constant catholic potential of 0.45 V for 15 min at room temperature. The WO3 films thus obtained are dark blue and were immediately rinsed with deionizer water and were dried in air.

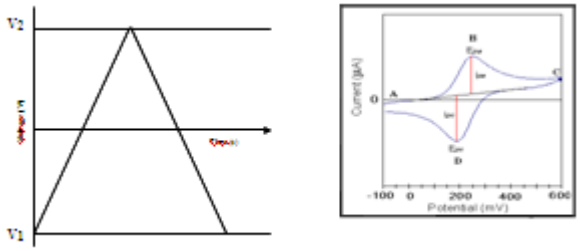
Film thickness is an important parameter in the study of the film properties. The thickness of the film was measured by Ambios XP-1 surface profiler technique



II. OPTICAL PROPERTIES

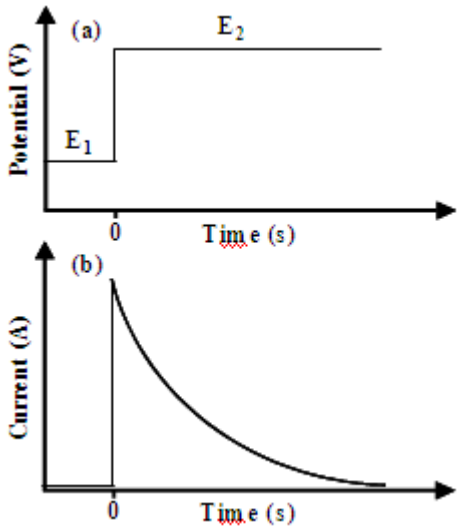
The optical transmission spectra for WO3 thin films in its colored and bleached states are studied. Using transmission spectra we determine the transmittance value in colored and bleached state accurately. The coloration efficiency is determined. The response time for coloration and bleaching is determined.

. Cyclic voltammetry (CV)



The response of a reversible redox couple during a single potential.

Chronoamperometry (CA):



CA experiment (a) potential-time waveform, and (b) the resulting current-time response.

III. THERMAL PROPERTIES

Thermal Properties:

The rate of heat conduction Q through any element such as window, wall, roof etc. under steady state can be written as

Q = A U □*T*

Where, A= Surface area

U= Thermal transmittance

ΔT= Inner and outer temperature difference.

Thermal transmittance and Thermal resistance :

U is given by equation,

U = 1/ R_T

Where, R_T is the total thermal resistance and is given by

R_T = 1 / h_i + (□ L_j / K_j) + 1 / h_o

h_i and h_o respectively, are the inside and outside heat transfer coefficients.

L_j is the thickness of window and K_j is the thermal conductivity.

U indicates the total amount of heat transmitted from outside to inside through window per unit area per unit time. The lower the U value the higher is the insulating value of the element.

Heat conduction, *H*:

$$H = \frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{x}$$

Where ΔQ/Δt is the rate of heat flow,

k = thermal conductivity,

A = total cross sectional area of conducting surface,

ΔT =temperature difference, and

x = thickness of conducting surface separating the 2 temperatures.

Dimension of thermal conductivity = M1L1T−3K−1

Rearranging the equation gives thermal conductivity:

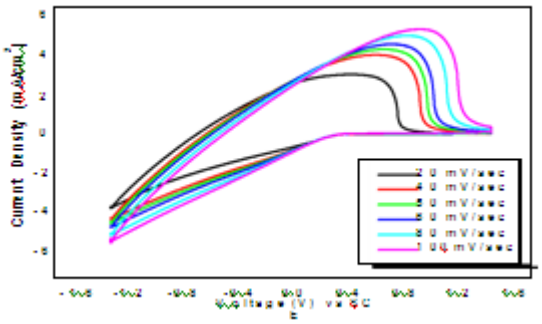
$$k = \frac{\Delta Q}{\Delta t}\frac{1}{A}\frac{x}{\Delta T}$$

U= Q / A (dT)

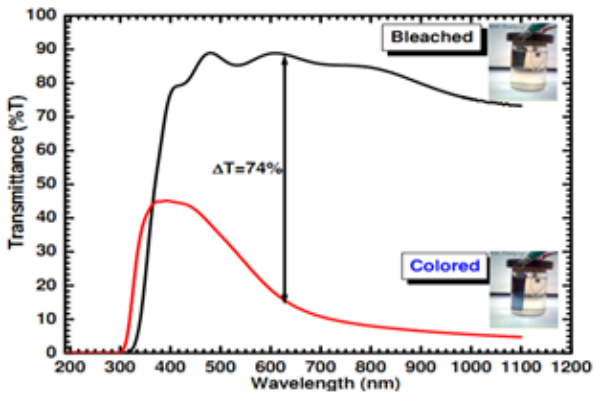
where Q = rate of heat transfer

A = the area; and

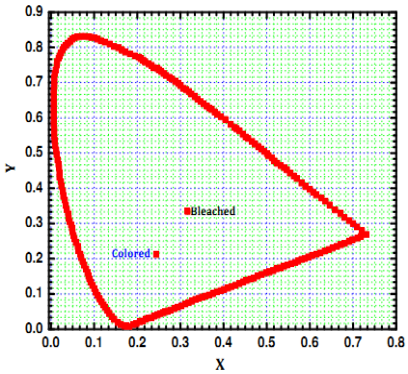
dT= the temperature difference.



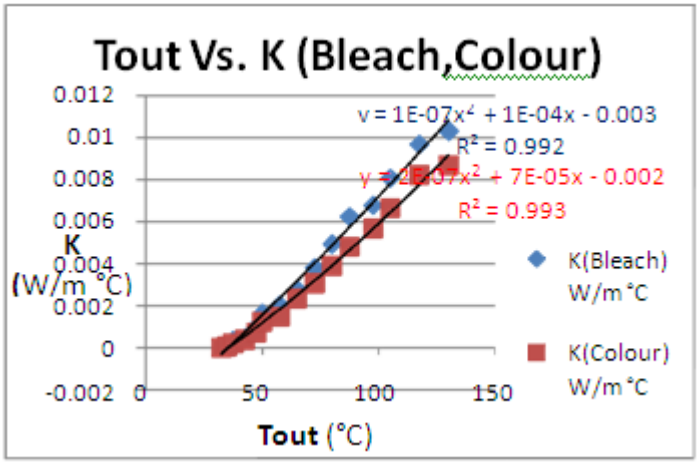
Cyclic voltammograms of WO3 sample recorded in 0.5M LiClO4-PC electrolyte at different scan rates with a potential window from +1.4 to -1.4V versus SCE.

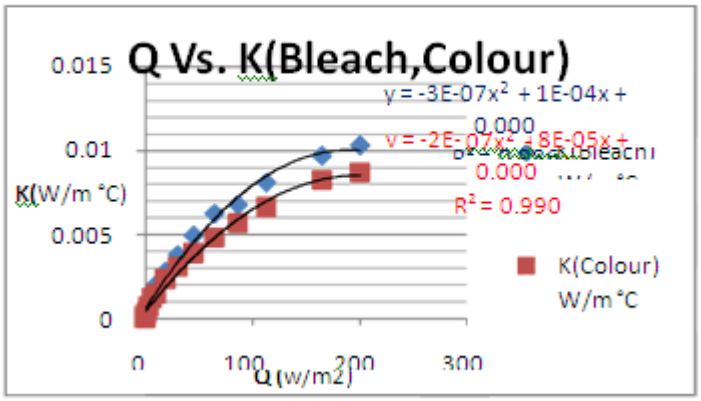


Optical transmission spectra of the WO3 thin films for colored and bleached states recorded in the wavelength range of 190-1100 nm. Inset shows the photographs of WO3 thin film in their colored and bleached state.

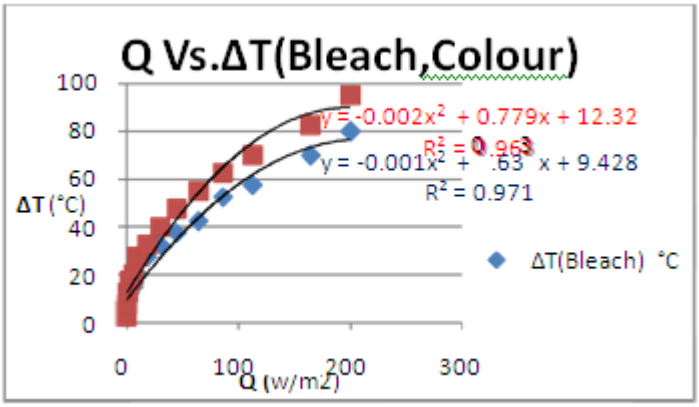


CIE 1931 chromaticity diagram showing the (x,y) color coordinates for WO3 thin film in their color/bleach state.





K values of the bleached and colored samples evaluated



Temperature difference verse heat gain properties of the samples

IV. CONCLUSION

The WO3 thin film electrochromic material is preferred for this project. WO3 is one of the important chromogenics that can be continuously switched between two optical states, and which shows many potential applications such as "smart windows", large area displays, automatic glare control in automotive rear-view mirrors etc. The optical properties and the thermal properties evaluated help to cause the temperature difference resulting in saving energy .

Results for optical properties of electrochromic device are presented. The optical transmittance difference (ΔT) in the colored and bleached states at 630 nm is found to be 74%. In colored state transmittance is nearly 15% and in bleached state it is nearly 89%. The high Coloration Efficiency of 92 cm2/C was observed. Theresponse time of 10.28 for coloration (reduction) and 3.2 s for bleaching (oxidation) was observed. Further graphs explains the thermal properties of electrochromic device.

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