GRID 2024
12. INTERNATIONAL SYMPOSIUM ON GRAPHIC ENGINEERING AND DESIGN
14–16. NOVEMBER 2024

12th GRID SYMPOSIUM

Illumination with electrochromatic windows in virtual reality

Ratka Neskovska 1, Filip Popovski 1, Svetlana Mijakovska1, Hristina Dimova Popovska2
1 Faculty of Technical Sciences, Graphic Engineering and Design, Bitola, Macedonia
2 Faculty of Information and Communication Technologies, Bitola, Macedonia

Introduction

Electrochromatic materials are characterized by the change in their optical properties, when small ions and electrons are brought or taken in the presence of an external electric field. The optical properties of electrochromatic materials are reversible, i.e. by changing the polarity of the applied voltage, the material returns to its initial state. Optical changes occur when applying a low-power electric with low voltages from one volt to several volts. A large number of materials, organic and inorganic, in liquid or solid state, that have electrochromic properties [1]. In recent decades, the properties of these materials have been widely explored for the possibility of their use in different optical devices. The electrochromatic properties of various materials depend on the method of their production, with great influence of the structure, stoichiometry, the presence of water in the film. When describing the electrochromatic properties of a material, a detailed description of the procedure for obtaining it should be given. Electrochemical properties also show thin films from CuO, Cu2O [2] [4] [5]. These films can be obtained by different methods: thermal oxidation at lower or higher temperatures, electrode deposition, dispersion, anode and chemical oxidation of a copper plate and others. In order to see the optical changes occurring in electrochromatic films when changing the polarity of the outer field, the films should be deposited on a transparent conductive substrate. Thus, the methods for producing thin copper oxide electrochromic films are limited by the substrate on which they are deposited. In this scientific work, the films were deposited on glass substrates by the chemical deposition method of two solutions [6]. After that, an electrochromic test device was constructed to record the transmission coefficients of the films in the visible part of the spectrum in the interval of the wavelength of the fallen radiation from 300 to 850 nm in a state as obtained in a colored and shaded state [4]. Furthermore, the absorption coefficients of the film were calculated in the three states and the obtained results were used to determine the intensity of the transmitted radiation that passes through the films and the mean value of the transmission coefficients, and for the fallen radiation the solar spectrum of AM 1.5 was taken. The mean value of the transmission coefficient for the three states of the film is taken to simulate the illumination of the interior of a real object, when the existing windows would be the examined electrochromic films in the state as they were obtained in a colored and shaded state. The simulation is using Quest3D virtual reality software. In this model, a virtual environment of a realistic model of the sports hall in Skopje was made. The hall is 40m x 20m, which includes a panel for 500 spectators. To create virtual environment, the following steps were made: collect data from the real model (appearance, dimensions), creating the same model in 3D Studio Max, importing models in the virtual reality software Quest3D and connect the models with the appropriate channels and their programming.

Results

Transmission, reflection and absorption, as well as emission, are optical characteristics that can be measured experimentally and from the obtained values some conclusions can be done. The coefficient of transmission of electrochromatic films is change with the state of the film, ie it is different in the shaded and colored state. In this study, the coefficient of transmission of films in the visible part of the spectrum was recorded in the interval of the wavelength of the fallen radiation from 300 to 850 nm, in a colored and shaded state. The measurements were performed using the Varian Cary 50 Scan UV-Visible Spectrophotometer. The coloring and shading of films was performed with a voltage of -4 V and +4 V, respectively. The intensity of the spent radiation is in a wave interval of 350 to 820 nm. The film have a value of 182.41 W/m2, for the colored state the value is 104.02 W/m2 and for the shaded state W/m2. The sum of the intensity of the fallen radiation in the same wave interval is 520 W/m2. For the mean value of the coefficient of transmission in the same wave interval, for the condition in which the film is obtained, in the colored and shaded state, the values are 35.08%, 20.0% and 57.60%, respectively. From the presented results it can be concluded that films of copper(I)oxide are suitable for modulating the infrared radiation in the visible part of the spectrum. A graphic representation of the dependence of the intensity of radiation through the films as a function of the wavelength of the fallen radiation is given in Figures. The obtained results for the mean value of the transmission coefficient in the three conditions of the film, were used for simulation of the interior illumination of a real object, a sports hall in Skopje, when the existing windows would be examined as electrochromic films in the state as they were obtained, in colored and shaded condition. The hall is 40m x 20 m, which includes a panel for 500 spectators. The simulation was made using the virtual reality software Quest3D . Only external lighting was taken and the interior was switched off.

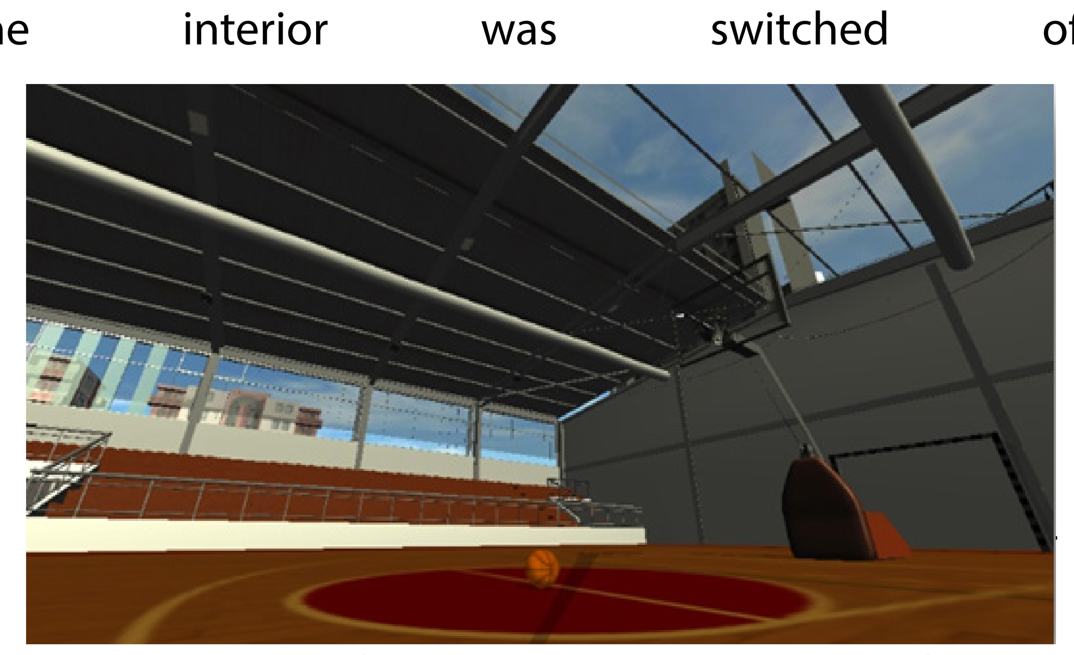

Figure 1: Simulation of the illumination in the interior of the sport hall in daylight. The interior lighting is off

Figure 2: Simulation of the illumination in the interior of the sport hall in daylight, modulated when passing through the electrochromatic film in a state as it is obtained. The film's transmission coefficient main value is 35.08%. The solar spectrum AM 1.5 is fallen light and the interior lighting is switch off

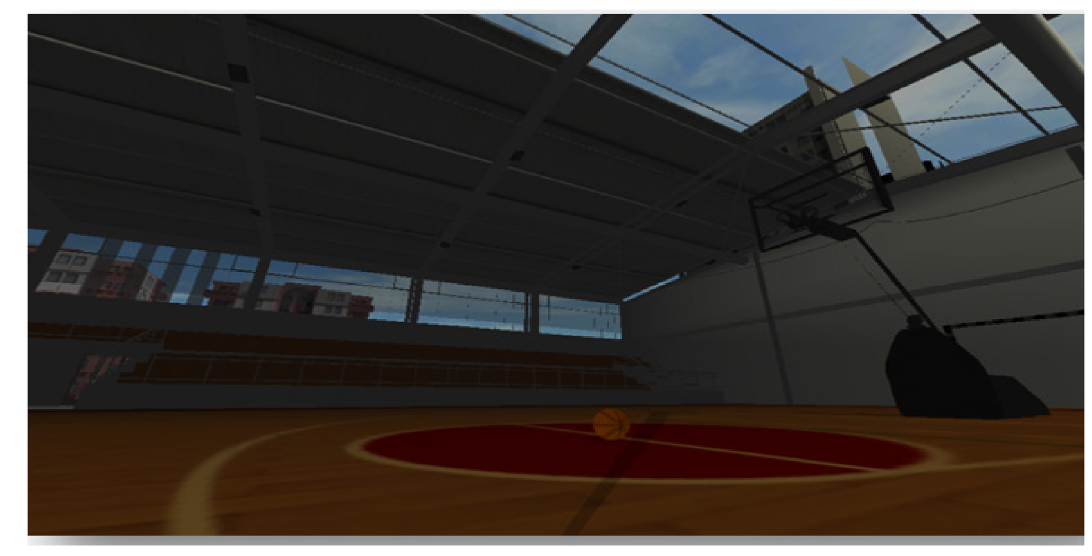

Figure 3: Simulation of the illumination in the interior of the sport hall in daylight, modulated when passing through the electrochromatic film in a shaded state. The film's transmission coefficient main value is 57.06%. The solar range AM 1.5 is fallen light and the interior lighting is switch off

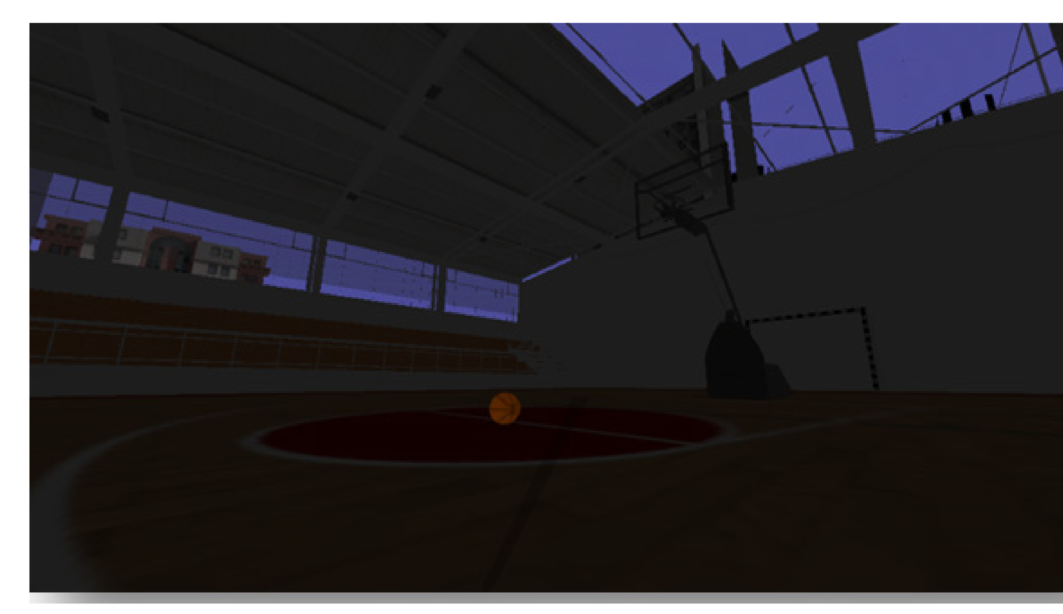

Figure 4: Simulation of the illumination in the interior of the sport hall in daylight, modulated when passing through the electrochromatic film in a colored state. The film's transmission coefficient main value is 20,0%.The solar range AM 1.5 is fallen light and the interior lighting is switch off

Discussion /Conclusion

In this scientific paper were obtained electrochromic films from copper(I)oxide in a fast, simple, economical and environmentally friendly method with chemical deposition of two solutions. The mean value of the transmission coefficient of the films in the visible part of the spectrum in the state as it is obtained is in a shaded and colored state are 35.08%, 57.60% and 20.0%. The values for the transmission coefficient were used for simulation of the lighting of a real object, the sports hall "Forza" in Skopje, in case when an electrochromatic film of copper(I)oxide is set on existing windows of the building in a colored and shaded condition. Simulations were made with the virtual reality software Quest3D and show that these films can be used in real world so-called "Smart windows".

REFERENCES

Granqvist C.G., (1995). Handbook of Inorganic Electrochromic Materials, Elsevier, Amsterdam

Neškovska R., Ristova M., Velevska J., Ristov M., (2007). Electrochromism of the electroless deposited cuprous oxide films, Thin Solid Films, Volume 515, 4717-4721
https://doi.org/10.1016/j.tsf.2006.12.121

Popovski F., Nedelkovski I., Mijakovska S., (2014). Generating 3D Model in Virtual Reality and Analyzing Its Performance, International Journal of Computer Science and Information Technology, Volume 6, 123–128.
http://doi.org/10.5121/ijcsit.2014.6609

Ristova M., Neškovska R., Mirceski V., (2007). Chemically deposited electrochromic cuprous oxide films for solar light modulation, Solar Energy Materials and Solar Cells, Volume 91, 1361-1365
https://doi.org/10.1016/j.solmat.2007.05.018

Ristova M., Mirceski V., Neškovska R. (2015). Voltammetry of chemically deposited Cu x O electrochromic films, coated with ZnO or TiO2 electrocatalyst layers, Journal of Solid State Electrochemistry, Volume 19, 749-756.
https://doi.org/10.1007/s10008-014-2666-x

Ristov M., Sinadinovski G., Grozdanov I., (1985). Chemical deposition of Cu2O thin films, Thin Solid Films, Volume 123, 63-67
https://doi.org/10.1016/0040-6090(85)90041-0.

Ristov M., Sinadinovski G., Mitrevski M., Ristova M., (1997). Deposition of SnO2 Thin Films by Spray Pyrolysis from SnCl2 water solution, Annuaire – Physique 47, 113-120

Smith G., Gentle A., Arnold M., Cortie M., (2016). Nanophotonics-enabled smart windows, buildings and wearables, Nanophotonicss, Volume 5, 55-73
https://doi.org/10.1515/nanoph-2016-0014