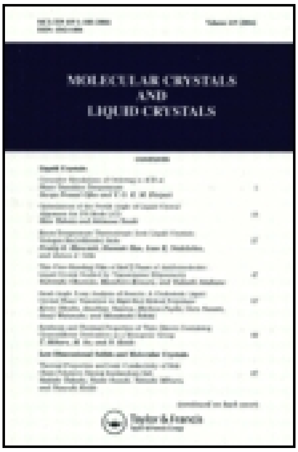

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Effects of Thin Film Deposition on Fabrication of Switchable Mirror

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Effects of Thin Film Deposition on Fabrication of Switchable Mirror

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In this paper we studied switchable mirrors for application to transparent flat panel displays. The typical structure of switchable mirror has configuration of MgNi/Pd/Ta_2O_5/$HxWO_3$/ITO. In this study photocatalyst layer (TiO_2 or Nb_2O_5) was used between Pd and Ta_2O_5 layers. These layers were prepared by RF magnetron sputtering method utilizing TiO_2 and Nb_2O_5 targets under various conditions and their electrochromic properties were investigated by using FE-SEM, EDAX and Nano View system. The transmittances of the Nb_2O_5 and the TiO_2 thin films, could be optimized in the switchable mirror as photocatalyst layer, where they were deposited under the power of 80 W and 70 W, respectively, by the RF magnetron sputter. The characteristics of Nb_2O_5 and TiO_2 transmittance are the outstanding at 80 W, 70 W respectively.

Keywords Electrochromic film; TiO_2; Nb_2O_5; Switchable mirror; Photocatalyst layer

Introduction

Recently switchable mirrors have attracted considerable attention due to their potential application to energy saving windows for houses, automobiles and display applications [1]. We developed a noble solid state switchable mirror by using thin film of Mg-Ni alloy as electrochromic materials [2–4]. The switchable mirrors change their optical properties reversibly between transparent and reflective states as a result of hydrogenation and dehydrogenation of thin films. When Ta_2O_5 is used as a solid electrolyte layer, it exhibits good conductivity due to high proton content and fast transfer of protons [5–7]. However Ta_2O_5 layer has poor durability in the cycling test. In this study we introduced TiO_2 or Nb_2O_5 photocatalyst layer between Pd and Ta_2O_5 layers and investigated its effects on durability and the color change characteristics according to the variable voltage. The switchable mirror had a multilayer structure of MgNi/Pd/Photocatalyst layer/Ta_2O_5/$HxWO_3$/ITO deposited on a transparent substrate [8–9]. The layers in the switchable mirror had functions of optical switch layer, Pd buffer layer, photocatalyst layer, solid electrolyte, ion storage layer, transparent conductor. In this study, transmittances of the Nb_2O_5 and the TiO_2 film

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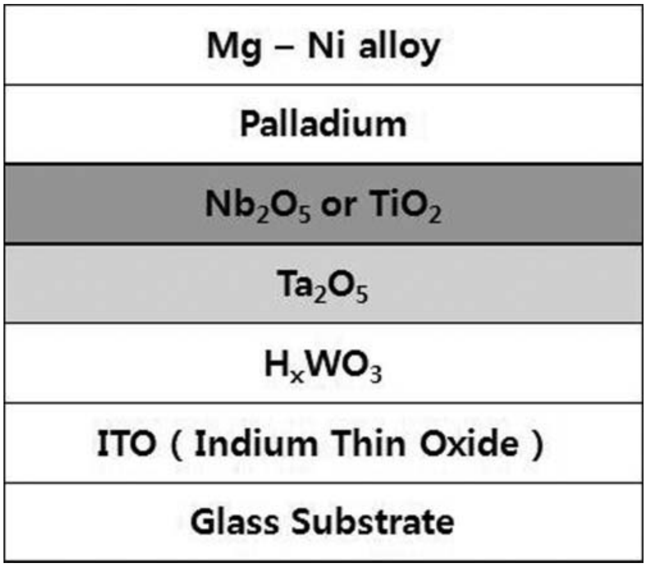

Figure 1. Cross sectional diagram of switchable mirror with Mg-Ni alloy as external electrode.

as photocatalyst layer were evaluated in terms of the thickness and thin film deposition conditions.

Experimental

Fabrication of Switchable Mirror

Figure 1 shows the schematic diagram of a solid state switchable mirror utilizing Mg-Ni alloy thin film as an electrochromic electrode. This switchable mirror was prepared by deposition of thin films using magnetron sputtering method. First indium thin oxide(ITO) film was deposited on glass substrate by DC magnetron sputter. Under the pressure of 1.2 Pa the thickness of ITO layer was 150 nm and sheet resistance was 35 Ω/sq. The ion storage layer WO_3 layer also formed by RF magnetron sputter. The Ta_2O_5 thin film was deposited to a thickness of 500 nm by RF magnetron sputtering under a pressure of 1.0 Pa using argon gas. The photocatalyst layer was deposited to a thickness of 400 nm by magnetron sputtering utilizing Nb_2O_5 and TiO_2 target. The sputtering power was varied under the working pressure was 0.67 Pa. Then a voltage of 2 V was applied to the electrodes while the device was dipped in 0.5 M sulfuric acid solution. Protons were injected into the WO_3 layer to make $HxWO_3$ layer across the Ta_2O_5 layer. After proton injection Pd thin film was deposited to thickness of 4 nm on top of the photocatalyst layer by DC magnetron sputtering at 45 W power and working pressure of 1.2 Pa. The Mg-Ni alloy thin film was deposited by co-sputtering of magnesium and nickel targets to a thickness of 40 nm. Sputtering power ratio to the Mg and Ni target were 30 and 60 W, respectively.

Result and Discussion

We investigated the effects of multilayer surfaces on the electrochemical properties of switchable mirror. The thin film surfaces were characterized by using FE-SEM and Nano-View measurements. The characterization of thin films was carried out by using EDAX

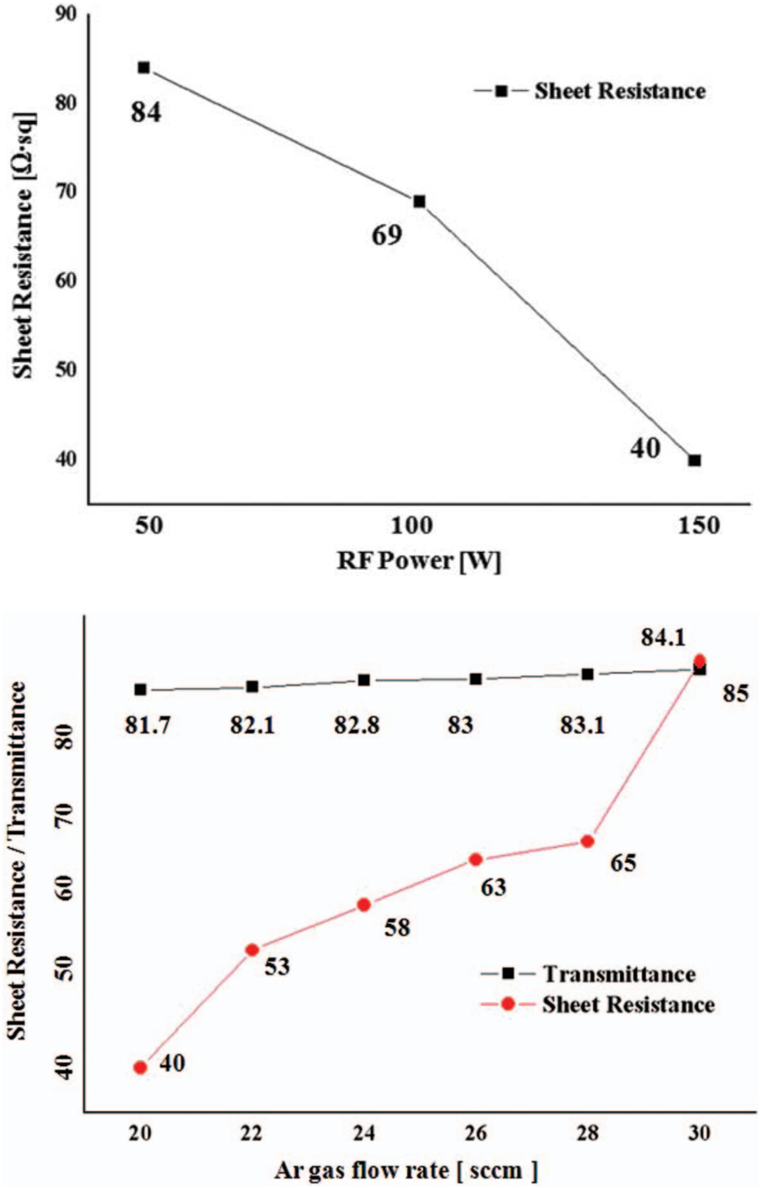

Figure 2. Electro-optical property of the ITO thin films by deposition conditions. (a) Sheet resistances of the ITO layer by RF power conditions. (b) Electro-optical property of the ITO layer with Ar gas flow rate.

system (Horiba-EX250). Figure 2 shows electro-optical property of the ITO films deposited by varying RF power and Ar gas flow rates. The sheet resistance of ITO coated glass was inversely proportional to the RF power. The sheet resistance of ITO layer was increased as the Ar gas flow rate was increased. The transmittance of ITO layer was slightly improved as the Ar gas flux was increased.

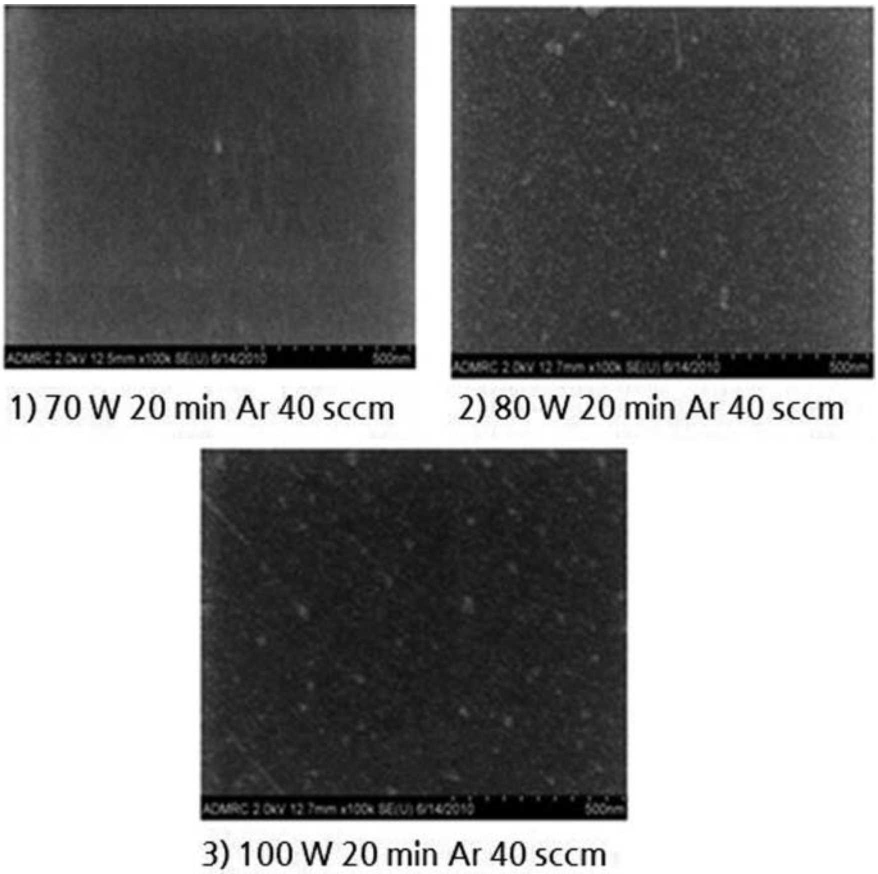

Figure 3. FE-SEM images of the TiO_2 layer by deposition conditions.

Figure 3 shows FE-SEM images of the TiO_2 thin films by deposition conditions. It was noted that TiO_2 thin films could be grown smoothly under 80 W RF power. However, the surface property of the TiO_2 was deteriorated above 100 W. The surface roughness (Ra) of TiO_2 layers were found to the 2.2 nm (70 W), 3.3 nm (80 W) and 5.1 nm (100 W) as measured by Nano View system (x10 resolution). Figure 4 shows the UV-Vis spectrometric analysis of the TiO_2 photocatalyst layer which was best when deposited at RF power of 70 W.

Figure 5 shows the FE-SEM images of the Nb_2O_5 photocatalyst layer by deposition conditions.

Nb_2O_5 thin films had a quite flat and smooth surface at about 70 W RF power. The surface of Nb_2O_5 layer became rough above RF power of 100 W. The surface roughness (Ra) of Nb_2O_5 were measured to the 3.1 nm (50 W), 2.7 nm (70 W) and 3.9 nm (100 W) which exhibited minimum roughness at about 70 W RF power.

Figure 6 shows the transmittances of Nb_2O_5 layer in the visible region. It was noted that the transmittance of Nb_2O_5 layer was more dependent on the wave length in the visible region than the TiO_2 layer.

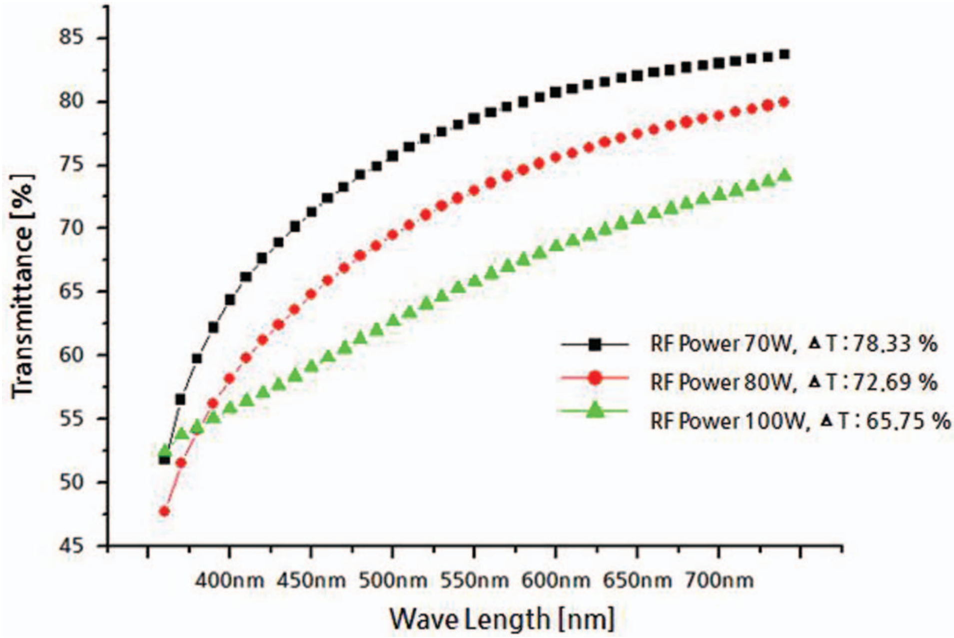

Figure 4. Transmittance of the TiO_2 layer by RF power conditions.

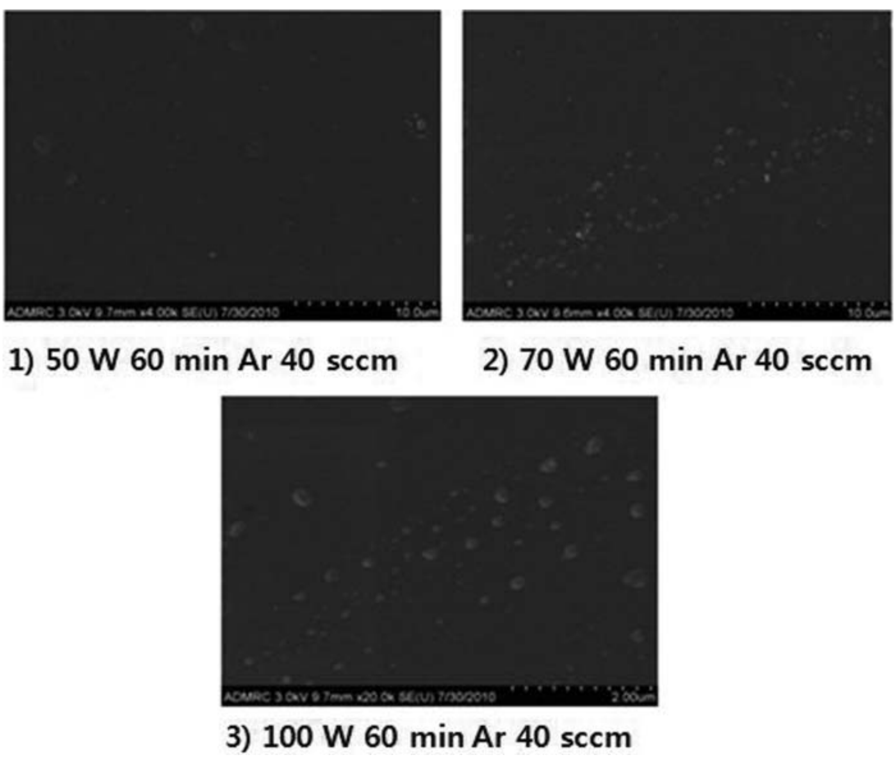

Figure 5. FE-SEM images of the Nb_2O_5 layer by deposition conditions.

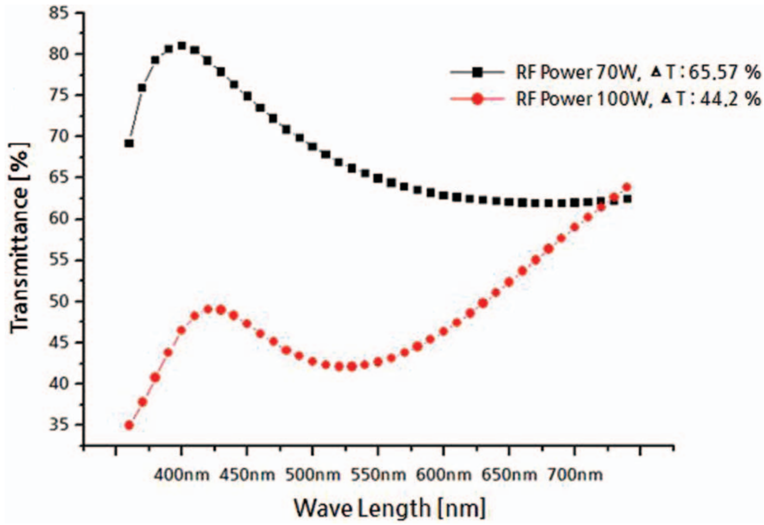

Figure 6. Transmittance of the Nb_2O_5 layer by RF power conditions.

Conclusions

In this study we investigated the deposition conditions of various layers of switchable mirror. ITO thin films exhibited good electro-optical properties when deposited at 100 W RF power and flow rates of Ar gas about 20 sccm, resulting in both low sheet resistance and high transmittance. As for the photocatalyst layer the TiO_2 thin film exhibited with low surface roughness and high transmittance in the visible region compared to the Nb_2O_5 layer. The switchabe mirrors fabricated under optimum conditions of each layers exhibited expected good switching property.

Acknowledgment

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