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Fine Pattern Preparation for Various Metals by using Selective Deposition based on Photochromic Surfaces

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1. Introduction

Organic electric devices have been recently attracted because of its light-weight, flexibility and low-cost production methods. We have reported a method to prepare metal patterns on organic layers by using vacuum evaporation without a shadow-mask [1-3]. The method is utilized to selective metal deposition on photochromic diarylethenes (DAEs) [4]. Fine Mg patterns on organic layers are able to be obtained simply by scanning a laser spot on the DAE layer. In this paper, we demonstrate selective deposition for Zn, Mg and Mn.

2. Selective Mg Deposition of Photochromic DAE

Photochromism is defined as a reversible color change upon photoirradiation between two isomers. Selective metal deposition is based on isomerization of amorphous DAE films. An uncolored film converts to a colored state upon UV irradiation and the colored state returns to the uncolored state upon visible light irradiation. Figure 1 demonstrates selective Mg deposition. An amorphous DAE film is prepared on a glass substrate. Parts of the film are colored upon UV irradiation. After that, Mg is evaporated to the whole of the substrate without a shadow-mask. As a result, metal Mg vapor is deposited on the colored film, but not on the uncolored film.

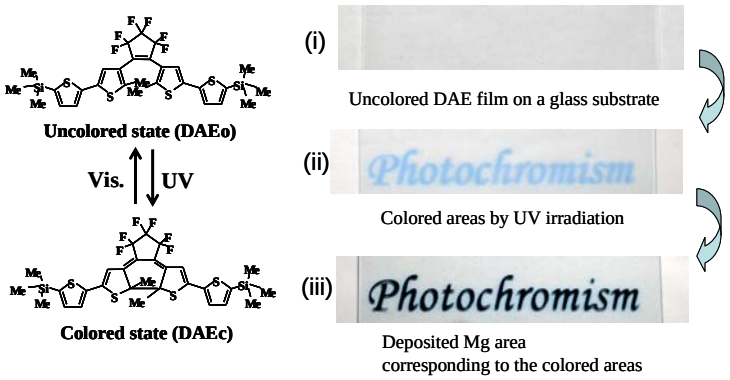

Fig. 1 Selective Mg deposition on photochromic DAE surfaces

Selective Mg deposition is correlated with the change of glass transition temperature (Tg) of the amorphous DAE film based on photoisomerization. Tg is 95°C in the colored state and 32°C in the uncolored state. Surface molecular motion is enhanced on the film with low Tg. When Mg is adsorbed on the DAE film, weak interaction between Mg atoms and surface molecules, and active molecular motion result in Mg desorption from the uncolored surface.

Figure 2 shows the deposition rate dependence of Mg deposition property for the DAE films with various isomerization ratios. Mg was deposited even on the uncolored surface at the deposition rate of 10 nm/s, whereas not deposited on the colored surface at the rate of 0.04 nm/s. The deposition threshold was shifted to the uncolored side by increasing the deposition rate. The deposition rate dependence means that the collision of Mg atoms during migration on the surface is an important factor for nucleation of the Mg film formation on organic surfaces [5].

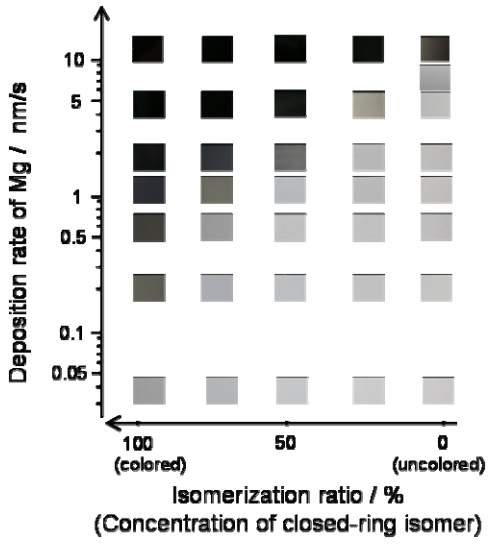

Fig. 2 Mg deposition property at various deposition rates

3. Selective Deposition for Zn, Mg and Mn

Mg deposition property strongly depends on the Mg deposition rate. This suggests that selective deposition would be available for other metals by adjusting metal deposition rate. Various metals were tested to investigate the deposition property by changing a deposition rate. Selective deposition for Zn, Mg and Mn were observed at the rate of 3 nm/s, 0.5 nm/s and 0.05 nm/s, respectively, as shown in Fig. 3. Selective deposition for other metals such as Al, Au and Ag was not observed in the range of these deposition rates, but could be possible at lower deposition rate.

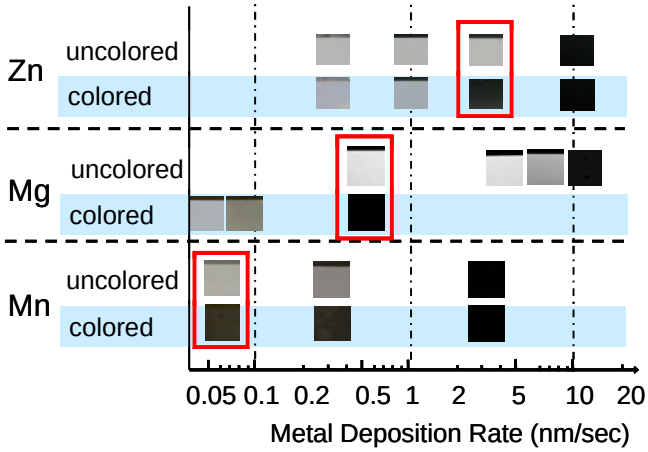

Fig. 3 Selective deposition for Zn, Mg and Mn

To investigate an origin of the difference of the deposition rate dependence among Zn, Mg and Mn, AFM images of metal crystals deposited on a glass substrate were recorded as shown in Fig. 4. Relatively large Zn crystals and small Mn crystals were observed compared with the Mg crystals. In general, high substrate temperature during deposition enhances the crystal growth because of active migration on the surface. If the interaction between the metal atoms and surface molecules, i.e. van der Waals force, is weak, metal atoms on the surface are easy to migrate and large crystals are formed. These results indicate that the crystal size reflects an interaction intensity of metals, and Zn has the weakest interaction in the three metals.

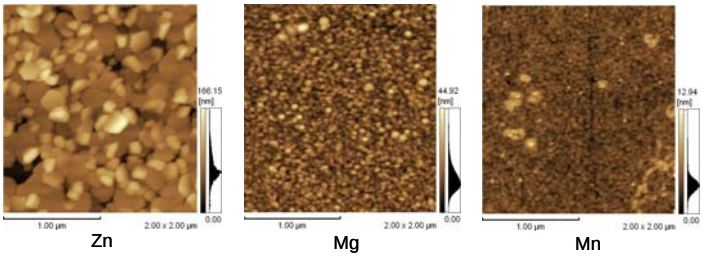

Fig. 4 AFM images of metal crystals

Figure 5 shows demonstrations of fine metal patterning using selective deposition. The colored lines were formed by blue laser scanning on the DAE film. After that Zn, Mg and Mn were evaporated to the sample at the deposition rate of 3 nm/s, 0.5 nm/s and 0.05 nm/s, respectively. As a result, fine metal patterns corresponding to the isomerization patterns were achieved successfully by using mask-less deposition.

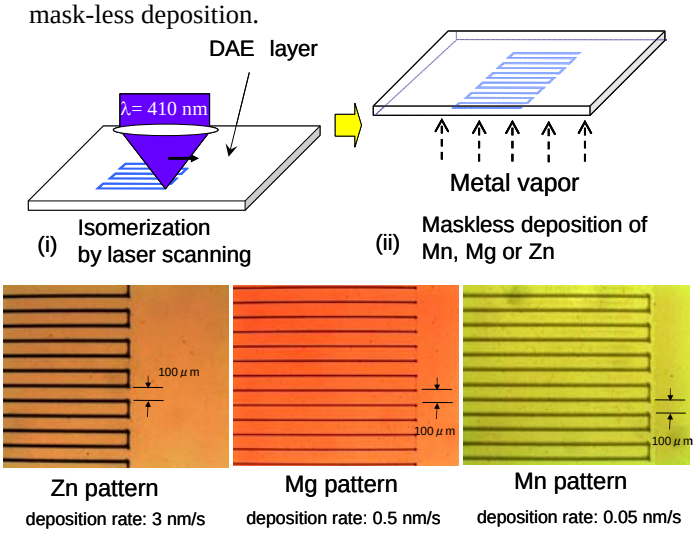

Fig. 5 Fine Zn, Mg and Mn pattern preparation by laser scanning with mask-less deposition

4. Conclusion

We reported selective metal deposition on the photochromic diarylethene. Selective deposition for Zn, Mg and Mn was observed at the deposition rate of 3 nm/s, 0.5 nm/s and 0.05 nm/s, respectively. The difference of deposition property for Zn, Mg and Mn was originated from the difference of the interaction intensity of each metals. Fine metal patterns were achieved by adjusting the metal deposition rate.

References

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