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Control of Orientation of Vanadyl-phthalocyanine Thin Film Prepared on Au Substrate

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1. Introduction

Nonlinear optical materials have much attention as materials in optical signal processing systems. Their nonlinear optical properties strongly depend upon the π -conjugated length of molecule, the orientation and the packing density of molecules deposited on a substrate. The orientation of organic nonlinear optical thin film is improved with increasing the substrate temperature [1]. The orientation improved of the thin film enhances the third-order nonlinear optical property [2]. Therefore, The control of Vanadylphthalocyanine (VOPc) single crystal film deposited on the substrate is important for nonlinear optical properties. We investigate the orientation of VOPc thin film deposited on Au (111) substrate by vacuum deposition. VOPc molecules deposited on Au (111) substrate are parallel to the substrate at 200 °C and grow epitaxially.

2. Experiment

The source material used was VOPc powder supplied from Kanto Kagaku Company. It was inserted into a cell and was preheated at 380°C for two hours. Au substrate was setting to a holder. The main chamber of vacuum deposition equipment was at about 10^{-4}Pa, and the Au substrate was preheated for one hour at a certain temperature. The evaporating temperature was kept at a 380 °C. The substrate temperature during the deposition of VOPc molecules was kept at a certain temperature.

Table2 Preparing conditions of VOPc thin films of Samples 1~5

Samples	1	2	3	4	5
Substrate	Au (111)				
Vacuum	$2\sim3\times10^{-4}$Pa				
Preheating temperature of evaporating source	380℃				
Preheating temperature of substrate	25	50	100	150	200℃
Preheating time of substrate	60 min.				
Substrate temperature	25	50	100	150	200℃
Evaporating time	120 min.				

The time was 120 min. The film thickness of the VOPc thin film deposited on the Au substrate was about 80nm. Table 1 shows the preparing conditions of VOPc thin films.

3. Results and discussion

Fig. 1 shows the absorption spectra of VOPc thin films prepared at different substrate temperatures.

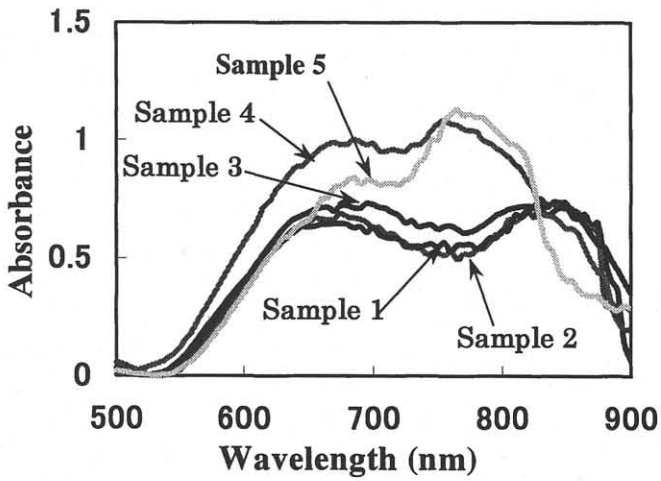

Fig.1 VIS/UV spectra of Samples 1, 2, 3, 4 and 5.

The absorption spectra of Samples 1, 2 and 3 have an absorption peak at 830nm in the Q band region. This indicates that VOPc thick films have a high packing density on Au substrate. The absorption spectra of Samples 4 and 5 have an absorption peak at 780nm and a shoulder at 810nm. This suggests that Samples 4 and 5 are films deposited epitaxially [3]. Fig. 2 shows the X-ray diffraction (XRD) profiles of VOPc thin films prepared at different substrate temperatures. The XRD profiles of VOPc thin films prepared at the substrate temperatures of 25, 50 and 100 °C show that VOPc molecules deposit with a mixture of perpendicular and parallel molecules on the substrate. The XRD profiles of VOPc thin films prepared at 150 and 200 °C show that VOPc molecules are parallel to the substrate. Fig. 3 shows the XPS spectra of Samples 1, 3 and 5. Sample 5 has a lower X-ray photoelectron intensity than Samples 1 and 3.

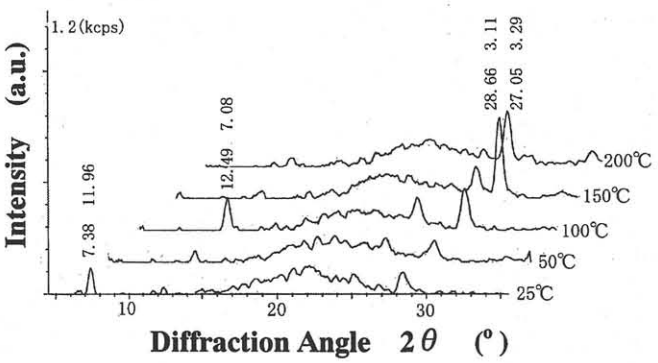

Fig. 2 XRD profiles of Samples 1, 2, 3, 4 and 5.

This corresponds well to a fact that the packing density of Samples 1 and 3 are higher than that of Sample 5. Figs. 4 and 5 show the AFM images of Samples 2 and 4.

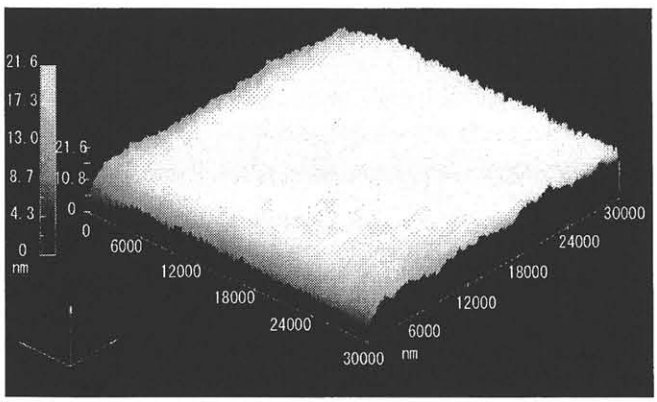

Fig. 3 AFM image of Sample 2.

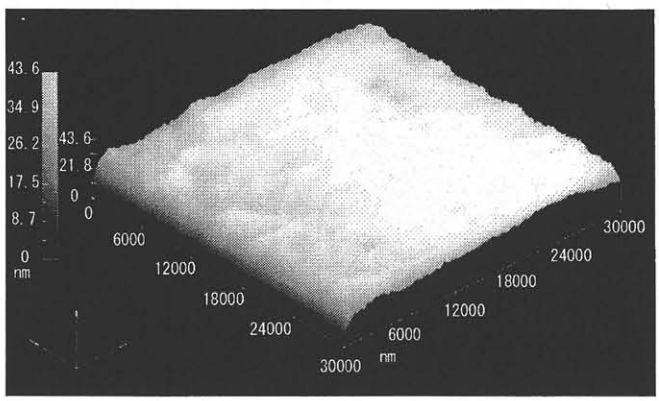

Fig. 4 AFM image of Sample 4.

Needle crystals on the surface of Sample 2 are observed from AFM image. This means that VOPc molecules deposited on the substrate are perpendicular to the substrate. The surface of Sample 4 is smoother than that of Sample 2. In other words, VOPc molecules deposited on the substrate are parallel to the substrate. These results indicate that the orientation of VOPc molecules can be controlled by substrate temperature.

4. Conclusions

VOPc thin films were prepared by a vacuum deposition on an Au (111) substrate. VOPc thin films have polycrystalline at the substrate temperature of 25, 50 and 100 °C and grow epitaxially at 150 and 200 °C.

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