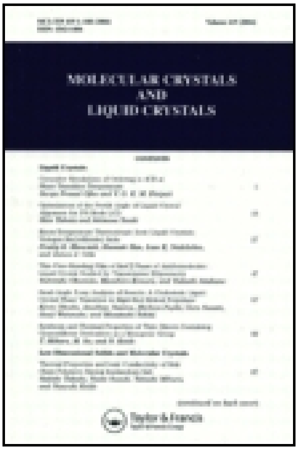

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Microscopic Patterning on the Polysilane Films by the Laser Induced Grating Technique

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Microscopic patterning on polysilane thin film was observed after photoexcitation with an optical interference pattern using a nanosecond pulsed laser. The patterning processes were monitored by the diffraction of the probe beam. The observed diffraction signals consist of the transient grating component due to the temperature change and the permanent grating component due to a chemical reaction. It was found that the microscopic pattern was destroyed with prolonged laser radiation. The created microscopic pattern was observed by the optical microscope.

Keywords: polysilane; transient grating; permanent grating; microscopic patterning

INTRODUCTION

Polysilane compounds are easily oxidized by UV irradiation in air and their properties (refraction index, polarization, and hydrophilic character, etc.) are quite modified by the reaction. The microscopic pattern of thepolysilane thin films can be applied to the optical memory, photonics bandgap, the alignment plate, and so on. Usually, such the microscopic patterns have been created by the ion etching technique [1] or lithographic technique with UV [2] or X-ray [3]. Recently, it was reported that the microscopic patterning was created by the optical interference pattern with continuous wave lasers [4]. In this paper, we created the microscopic pattern on polysilane thin films by using a nanosecond pulsed laser. At the same time, we observed the time profile of the patterning processes by the diffraction of the probe beam.

EXPERIMENTAL SECTION

The sample thin films of poly (dimethylsilane) [$(CH_3\text{-}Si\text{-}CH_3)_n$; n=10-20] were grown on the quartz substrate by the high vacuum deposition. The thickness of the films was 200nm. Pressure and flow rate of the vacuum deposition are 10^{7}-10^{8} Torr and 0.01-0.1 nm/s, respectively.

The experimental set up for this technique was already published elsewhere.[5-6] The sample materials were excited by the laser induced interference pattern created by crossing two excitation beams [Nd:YAG laser (266nm)]. The pulse width and repetition rate were 10ns and 5Hz, respectively. When the refractive index change (Δn) is also modulated along this interference pattern (grating), the grating can be observed by the diffraction of a probe beam [He-Ne laser (633nm)]. The obtained signals were detected by a photomultiplier tube, recorded with a digital oscilloscope, and analyzed with a microcomputer. The whole measurements have been done at room temperature (23°C).

RESULTS AND DISCUSSION

Fig. 1 shows the time profile of a diffraction intensity after the photoexcitation of the polysilane thin films. The signal consist of two components; decaying component and a constant component. The decaying component should be attributed to the thermal grating, which is created by the thermal energy from the nonradiative relaxation of excited molecules.[5-6] On the other hand, the constant component should be attributed to the modulation of

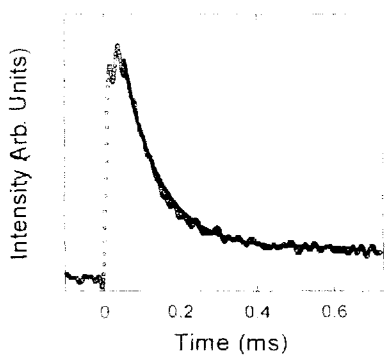

Fig. 1 Time profile of the diffraction signal of the polysilane thin films.

densities of product and reactant by photochemical reaction (permanent grating; PG). [7-8] By the diffraction theory, the diffraction intensity is proportional to the square of the refractive index change. We can fit the time profile of diffraction signal with an exponential function; $[\,A\,\exp(-t/\tau) + B\,]^2$. Solid line in Fig. 1 is the best fitted line. A should be proportional to the released heat energy. τ is the decay rate constant which represents the heat conduction time. B should be proportional to the density of the reaction products (oxidized silane). Therefore, we can observe the oxidation processes by observing B values; signal intensities of PG.

Fig. 2 shows the laser shot dependence of B. It became larger with the increasing of laser shot. When after 60 shot, B became maximum values. Under this condition, we can see the diffraction beam even by the naked eye. After 60 shot, it became weaker. This fact suggests that the created microscopic pattern was destroyed with prolonged laser radiation. The created microscopic pattern was observed by the optical microscope. The pattern after 60 laser shot is shown in Fig. 3. Actually, microscopic pattern is created. By this method, we can create the microscopic pattern easily and simply. Fringe space (Λ) of this pattern is determined by the excitation laser wavelength (λ_{ex}) and crossing angle between two pump beams (θ) as $[\Lambda = \lambda_{ex}/2\sin(\theta/2)]$. Under an extreme condition such as $\theta = \pi$ rad, we could create the microscopic pattern with 133nm fringe space.

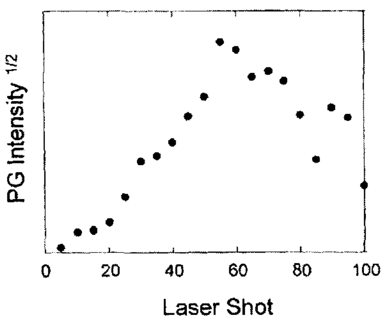

Fig. 2 Laser shot dependence of the signal intensities of permanent grating component (B values).

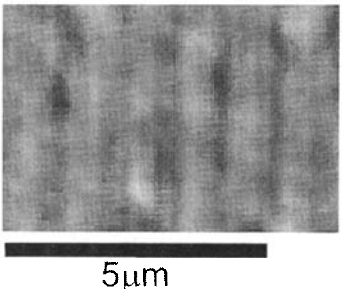

Fig. 3 Microscope image of the surface of polysilane thin film after 60 laser shot.

CONCLUSIONS

The pulsed laser induced grating technique is a powerful tool to create the microscopic patterning on polysilane thin films. By using this method, we can monitor the time profile of the pattering processes (heat generation and conduction, chemical reaction, etc.). Such the real-time monitoring should be advantageous to avoid the damage on the microscopic pattern caused by the generated heat or prolonged laser radiation.

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