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Photocatalytic Reaction of Transferred TiO_2 Films on Amorphous Quartz and Frexible Polyethylene Substrate by Laser Induced Forward Transfer

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Abstract: We have tried to transfer TiO_2 films that exhibit photocatalytic reactions on a amorphous substrates and flexible polyethylene films by a laser induced forward transfer (LIFT) method at room atmosphere. Raman spectra of LIFTed samples, which annealed at over 473 K, showed rutile-type TiO_2 peaks. The LIFTed TiO_2 samples on flexible films can decompose methylene blue by ultraviolet light irradiation. This indicated that LIFTed TiO_2 had a photocatalytic ability.

1. Introduction

Photocatalytic reaction for water splitting has been studied since the Honda-Fujishima effect[1], using TiO_2 based material, which is famous as a photocatalyst reaction such as hydrogen-fuel cells and deodorizing. TiO_2, based photocatalytic materials of $La_2Ti_2O_3$, $SrTiO_3$ and $SrLaTiO_3$ films were grown by sputtering or pulsed laser deposition (PLD) methods[2],[3]. However, it is difficult to obtain the epitaxial grown films, because of lattice constant. Thus, it needs expensive substrates, whose lattice constants were matched with these TiO_2 based materials. Therefore, we focused on a laser induced forward transfer (LIFT) method[4] which could be transferred onto any type of substrates, and it was unrelated to lattice constants. As an annealed experiment, transfer material had been used TiO_2 film. In this study, we introduce a transferring technique and describe the qualities of TiO_2 films on amorphous quartz and polyethylene films by LIFT.

2. Experiment

2.1 Deposition of TiO_2 thin film by PLD

Figure 1 shows experimental system of PLD. TiO_2 films were deposited on amorphous quartz substrates by PLD. TiO_2 powder (Isihara Sangyo: ST-01) was pressed at 80 KN in mold, and formed bar sharped as a laser target. The laser target and the substrate were set in vacuum chamber. A N_2 gas (10 mTorr) was flowed into the chamber. A focused Nd: YAG laser (LOTIS: TEE LS 2147, wavelength: 266 nm, energy: 500 mJ/cm^2) was irradiated to laser target as a laser ablation source. Laser ablation plums were deposited on the substrates. Deposited films were used as base plates for LIFT as in the experiment described below.

2.2 Transfer of TiO_2 films on substrates by LIFT

A LIFT experimental apparatus is shown in Figure 2.The TiO_2 film and a receiver substrate (amorphous quartz, polyethylene films) were contacted, and put on the X-Y axes stepmotor stage (Sigma Koki: SGSP26-150,). The focused Nd: YAG laser (wavelength: 532 nm) was irradiated to the back of the base plates at room atmosphere. Dot-shaped TiO_2 was ejected from the base plate and transferred onto the receiver substrate. The X-Y stage was moved by one shot of the laser (distance: 500 μm/shot).Transferred TiO_2 samples on quartz substrates were annealed at 473 K and 773K. Relationship between crystals of these samples and annealed temperature was measured by Raman (Renishaw: Raman System 1000) using an Ar ion laser (Showa Optronics: GLG3103, power 514.5 nm, power: < 40 mW).

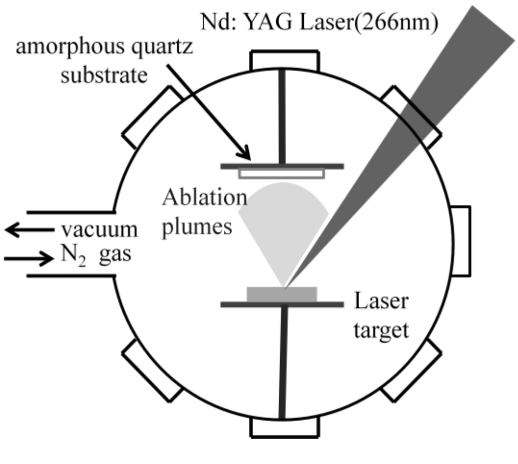

Figure 1. Experiment method of PLD

2.3 Decomposition of the methylene-blue solution by photocatalyst reaction

We prepared methylene-blue solution (Wako: 275-07895, 100 μmol/L). TiO_2 film samples (TiO_2 film on quartz, LIFT samples on quartz, LIFT samples on poly-ethylene) were dipped into quartz cells (10 mm × 10 mm × 45 mm), which filled with the methylene-blue solution. Black light (Toshiba:

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FL205 BLB-A, power: 20 mW/cm², wavelength: peak 360 nm) was irradiated to methylene-blue solution and TiO_2 samples. The transmittance of these solutions were measured by a spectrometer (StellarNet: EPP2000) at a wavelength of 665 nm.

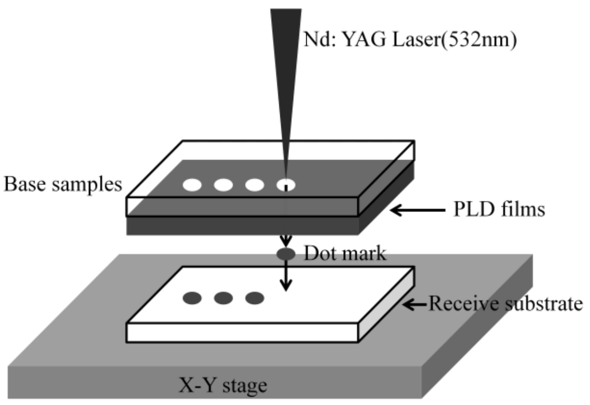

Figure 2. Experiment method of LIFT

3. Results

Figure 3 shows the Raman spectra of PLD films and LIFT samples. Rutile-type TiO_2 peaks (444 cm^{-1} and 610 cm^{-1}) were obtained at the PLD film. In contrast, there were no peaks at non-annealed LIFT sample. Annealed 473 K and 773 K samples were showed rutile-type peaks.

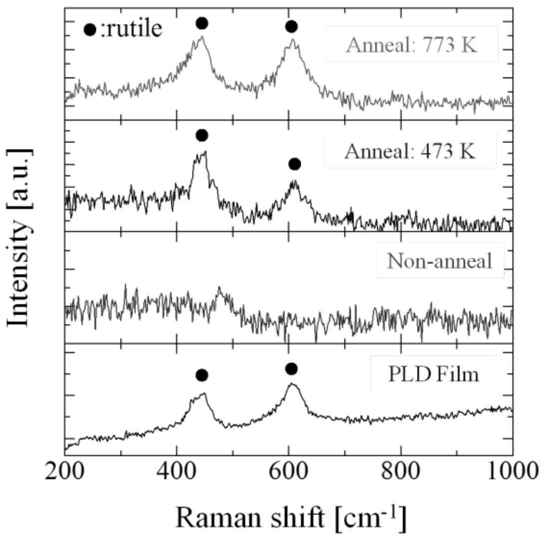

Figure 3. Raman spectra of TiO_2 samples

Figure 4 shows results of methylene-blue decomposition by photocatalyzed reaction. Methylene-blue solution was transferred to leucomethylene-blue by photocatalyst reaction.These colors were blue and clear, respectively. Transmittances of a without catalyst sample and a PLD film without light sample showed constant values about 6 %. Transmittance amounts of LIFTed samples at quartz and on poly were increased to 35.2 % and 32.0 %, respectively. As well as, these value of the PLD film was increased to 58.0 %. These results suggested that LIFTed TiO_2 have a photocatalytic ability.

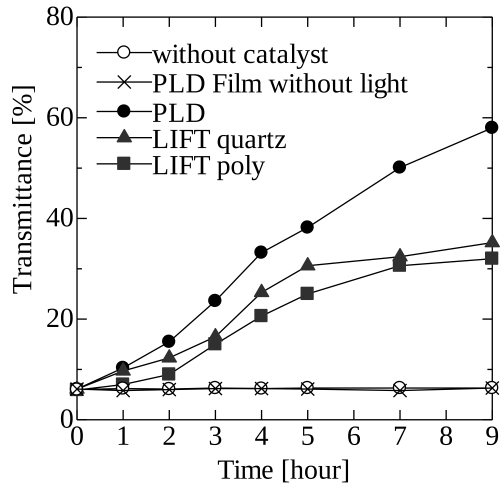

Figure 4. Decomposition of methylene blue solution

4. Conclusions

We had to transfer the TiO_2 films on amorphous and flexible substrates by LIFT at room atmosphere. LIFT samples had rutile-type TiO_2 crystals by annealing above 473 K. LIFT samples which irradiated UV light showed photocatalyst reaction. These results showed that TiO_2 films can deposit on various substrates by LIFT.

References

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