Laser processing of organic thin film

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Study of the organic thin film solar cell has been evaluated with the solar battery of the light receiving area of around 1 square centimetre. Upsizing of organic thin film solar cell is expected in future. When the organic thin film solar cell is modularized, the solar battery must be patterning to be connected to series and parallel. A femtosecond laser and a YAG laser are respectively focused on organic thin film on the XY stage. The laser powers to process are not same, because the absorptivity of the organic thin film is different substantially. The processed sections are measured by DFM. The processed depth reaches about 500nm. The processed surface is different respectively. The femtosecond laser is able to make clean hole. On the other hands, the heart influence is confirmed at the peripheral area of the hole made by YAG laser. The transmitted light at laser processed area is measured. The peak wavelength of absorbed light of PCDTBT processed by femtosecond laser is shifting to shorter wavelength. These phenomena may occur that the molecular size of PCDTBT changes small at the focal spot.

Introduction

The study of an organic thin film solar cell has been active since beginning of the 21st century. The conversion efficiency of the organic solar cell is now lower than an inorganic semiconductor solar cell. However, the progress is remarkable, and it is the device that future development is expected. However, the organic solar cell has a characteristic which is weak for heat.

The micro fabrication that used a short pulse laser attracts attention recently. Because the titan sapphire laser has the pulse width of femtosecond, it can perform little influence of the heat and it can be highly precise processing. [1,2] When the TW femtosecond laser beam is focused on the target, the non-linear interaction is induced such as multi-photon absorption and many photons ionization because the

femtosecond laser light has the high electric field.

Processing of the organic thin film has been carried out by irradiating a femtosecond laser light and the characteristic change of the organic thin film has been measured.

Experimental arrangement

The experiment arrangement is shown in Fig.1. The titan sapphire laser is operated with a single shot operation. A pulse half width is 100 fs, a wavelength is 800 nm and a laser power reaches 1 TW. Moreover, the YAG laser is used. The laser power is 23 MW, the wavelength is 1064 nm and the pulse half width is 15 ns. The laser power is respectively controlled by the ND filter. The pulse half width of the femtosecond laser light after passing through the ND filter does not change.

A PCDTBT or a PTB1 or a PTB7 on PCDTBT is used as targets. These organic thin films are made by the spin coating process. The organic thin film is made on the glass substrate. The glass substrate is able to spin at 500 rpm to 4000 rpm, and the organic solvent is made to drop on the glass substrate. The thickness is not constant at 500 rpm. Moreover, the surface is not smooth. On the other side, the thickness of organic film made at 4000 rpm is constant and the surface is flat. The organic thin film of layer type which is PTB7 on PCDTBT is made by a spray process after the spin coating process at 4000 rpm.

The laser is focused on these organic thin films on the XY stage by a parabolic mirror. The processed organic thin film is observed by optical microscope and DFM (Dynamic Force Mode) and measured a processed depth or a hole size. Moreover, the absorption wavelength characteristic is measured at the processed area and its peripheral edge.

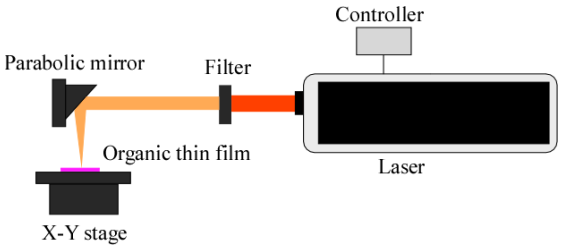


Fig. 1 Experimental arrangement.

3. PROCESSED EXPERIMENTAL RESULTS

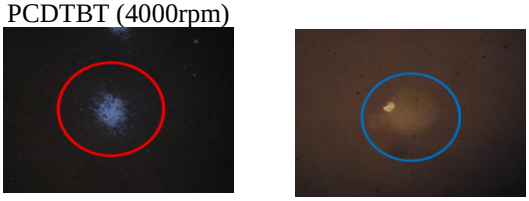
The processed sections observed by the optical microscope are shown in Fig. 2. These PCDTBT and PTB1 are processed with each laser. The femtosecond laser is able to process more neatly than the YAG laser, because the pulse width of the femtosecond laser is short, the processing is over before the energy of laser light is converted into heat.

The processed sections of PCDTBT observed by the DFM and the cross section images are shown in Fig. 3. The

cross section images show the date of arrowhead direction. The cross section processed by the YAG laser shows the rough face. The processed surface by the femtosecond laser is better than the YAG laser. The heat effect remains, because the pulse width of the YAG laser is longer than that of the femtosecond laser.

The surface condition of PTB7 on PCDTBT is shown in Fig. 4. This surface is not flat, because this organic thin film is made by the splay method after the spin coat process. The DFM images of the surface and the cross section after the femtosecond laser processing are shown in Fig. 5. The processed depth reaches 500 nm. The processing area is only organic made by spray method because the surface keeps the undulation made by the spray method.

PCDTBT (4000rpm)



YAG laser Femtosecond laser

Laser power

140 kW 360 MW

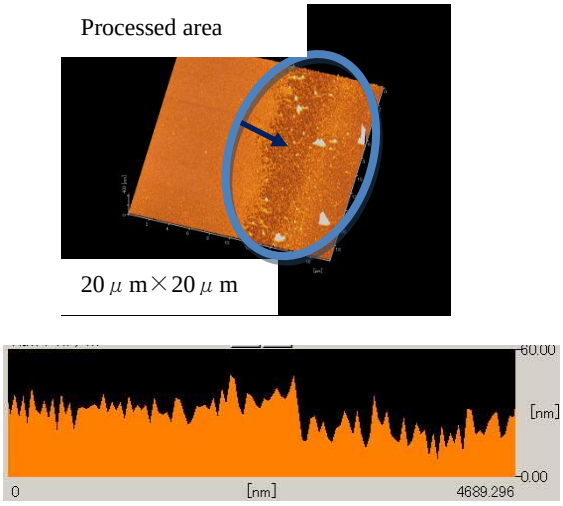
PTB1 (4000rpm)

YAG laser Femtosecond laser

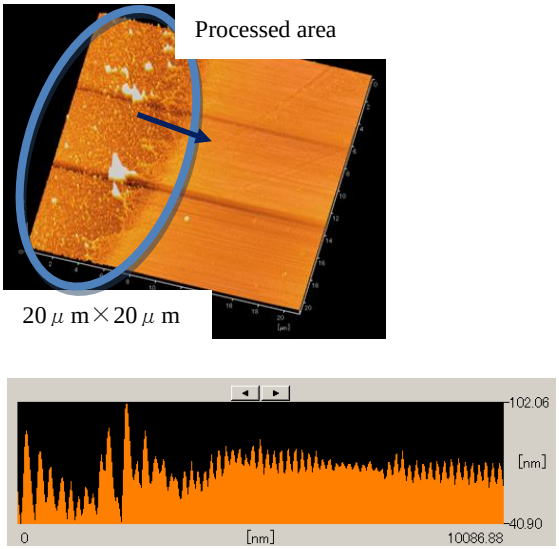
Laser power

140 kW 360 MW

Fig. 2 Microscope images of processed section



Femtolaser processed section (PCDTBT)



YAG laser processed section (PCDTBT)

Fig. 3 DFM images of processed section

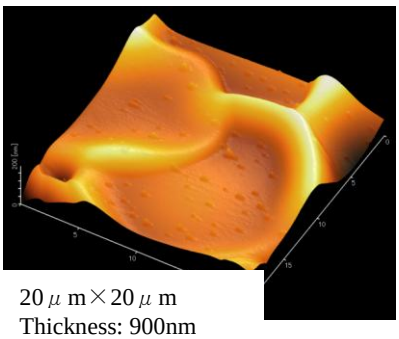


Fig. 4 Surface condition of PTB7 on PCDTBT

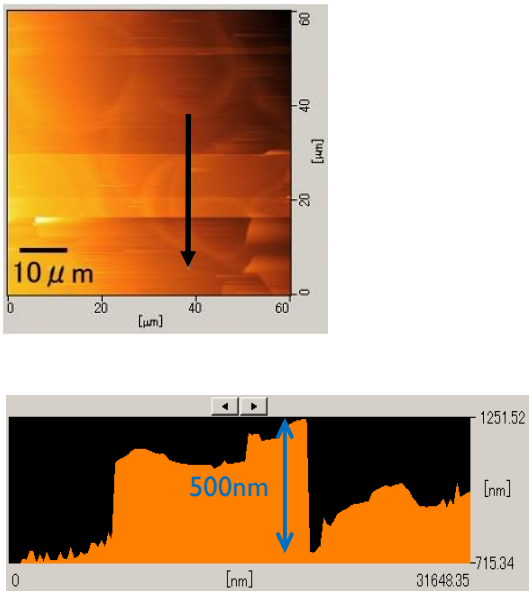


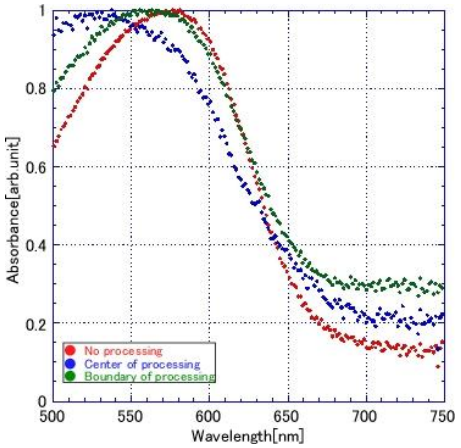
Fig. 5 Femtosecond laser processed depth at PTB7 on PCDTBT

4. ABSORPTION WAVELENGTH CHARACTERISTIC

The transmitted light at laser processed point is measured. The absorption wavelength characteristics of PCDTBT are shown in Fig. 6. The peak of PCDTBT absorption wavelength processed by femtosecond laser is shifting to shorter wavelength. These phenomena may occur that the molecular size of PCDTBT changes small at the focal spot.

5. RESULTS AND DISCUSSION

When YAG laser is focused on the organic thin film, the organic thin film has damage at edge of processed point. On the other hands, the processing by femtosecond laser does not have the damage, because the laser pulse width is



Femtosecond laser

Fig. 6 Absorbance wavelength characteristics of PCDTBT at processed area

very short and the heat is not conducted .

The transmitted wavelength at the processed point is investigated after the femtosecond laser is focused. The peak of the absorbed wavelength of PCDTBT at the processed point is shifting to shorter wavelength, because the molecular of PCDTBT may be decomposed.

References

[1] J. Kasparian and J.-P Wolf, Opt. Express 16, 466 (2008)
[2] M. Park et al., Optics and Lasers in Engineering 44, 138 (2006)

Acknowledgement

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