Development of frequency modulated photo-induced phase microscopy and the observation of photo-induced phase transition of liquid crystals

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Base substrates for photo-devices such as solar cells, photocatalysts, photo-responsive devices have typically spatially inhomogeneous structure. Time-resolved measurements have been utilized to understand the photo-induced phenomena for photo-devices, but these only give information on the values averaged over the inhomogeneous region. To clarify the structural dependence on the photo-induced dynamics, we have developed a new type of the phase microscopy, called frequency modulated photo-induced phase microscopy (FM-PM), by which temporal and spatial changes of photo-induced phenomena can be observed without any prior treatments for samples.

In this study, we observed the phase transition of a liquid crystal doped with light absorber, and a LED light induce the light absorption, causing the phase transition. The sample was a nematic crystal, 4-cyano-4'-pentylbiphenyl (5CB) with Disperse Red 1 and put into a liquid crystalline cell. The sample cell was heated up to 1.0 degree below the phase transition temperature (34.0 deg). The schematic diagram for the microscope is shown in Fig. 1. An excitation light was irradiated from the top side of microscope, while illumination light was irradiated from the bottom side. By synchronizing two electric signals, we were able to control the irradiation timing of each light. An ON-image was taken just after the irradiation of the excitation light. One the other hand, an OFF-image was obtained by taking the image after some delay time. When the photo-induced phenomena decays in the time close to the

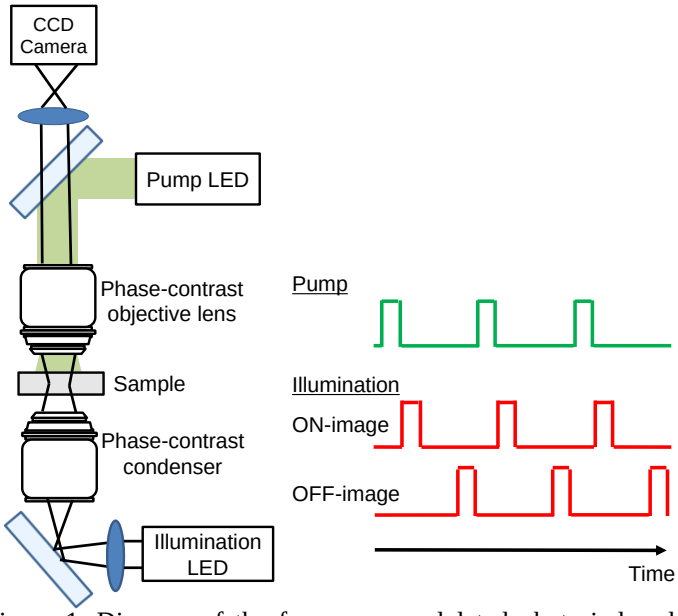

Figure 1. Diagram of the frequency modulated photo-induced phase microscope and irradiation timing of pump and illumination LEDs

interval of the excitation illumination, two images are different and, it is possible to visualize the refractive index change by the subtraction of each image.
A demonstration was made for the photo-induced phase transition of liquid crystals for different frequencies of the excitation light (Fig.1). We could observe the structural changes for the frequencies < 60 Hz, but not observed for the frequencies > 80 Hz. The typical size of the photo-induced region in the images became smaller as frequency. Since the inverse of the frequency corresponds to the decay time, the photo-induced structure became smaller as the decay time. At 20 Hz, we could observe a doughnut-like shape inside. Since the decay time corresponds to 50 ms, the photo-induced domain contracts on the order of 50 ms.

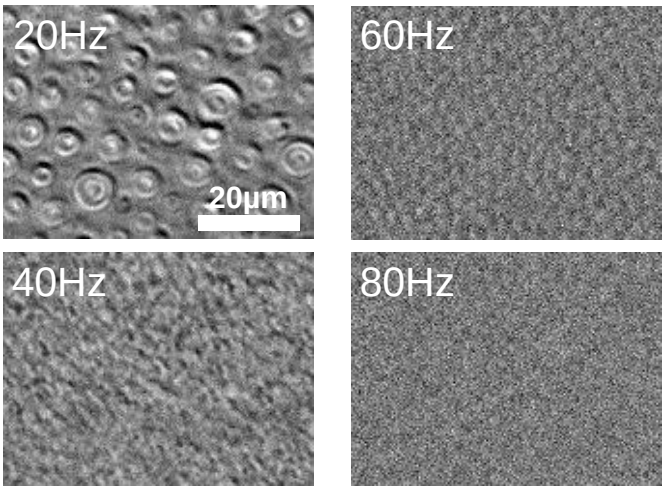

Figure 2. FM-PM images obtained at different frequencies

We could successfully visualize photo-induced phase transition processes of liquid crystals, for different lifetime, and other results observed in the faster time region will be also discussed in the conference.

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