19p-D6-1

In situ temperature measurement of oxide thin films at a nanosecond time scale during pulsed UV laser irradiation

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Irradiation with pulsed UV lasers is an attractive tool for the synthesis and modification of functional oxide thin films. Especially it has a great possibility to reduce processing temperature, enabling the use of plastic or glass substrates which is suitable for coming printable and flexible electronics. However, in order to minimize the damage to the substrate, quantitative understanding of temperature fields during laser irradiation is required. Therefore, we have developed an *in situ* temperature monitoring system with near-infrared sensors. Commercially available tin-doped indium oxide (ITO) thin films on glass substrates were used as test specimens. The thermal emissions from the specimens that were subjected to XeCl excimer laser irradiation were detected with an *in situ* measurement system.[1,2] The temperature was derived from the thermal emission signals on the basis of Planck's blackbody radiance spectral distribution law. A calibration was conducted by assuming that the observed plateau was equal to the melting point of ITO. Numerical simulation was also conducted with one-dimensional heat transfer equations. Figure 1 plots the time-dependent temperature profile of ITO thin films during the XeCl excimer laser irradiation. Temperature profiles were obtained above a fluence F = 225 mJ/cm^2. Temperature rising curves were reproduced well by numerical simulations. Meanwhile, the measured temperature turned to decrease faster than the simulated temperature. At higher fluences (F = 377 and 462 mJ/cm^2), plateau like regions suggesting the recalescence upon solidification were observed clearly in the cooling curves. Since phase changes were not taken into account in this simulation, this recalescence behavior was not reproduced in the simulation. Note that the measured temperature was scattered below T~1200 K, suggesting the lower limitation of temperature detection in this measurement system.

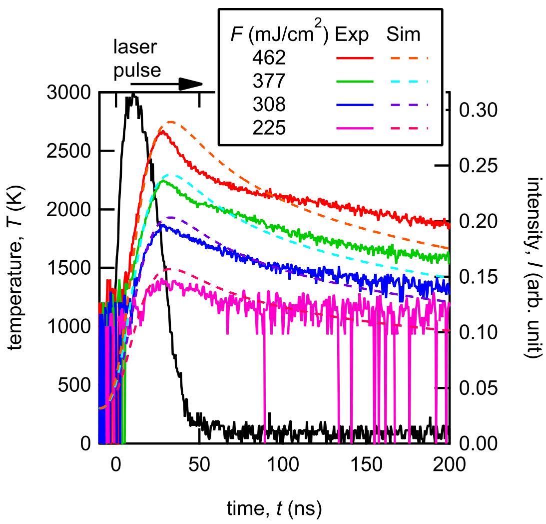

Fig. 1: Time (*t*)-dependent temperature (*T*) profile of ITO thin films on glass substrates subjected to the irradiation by a XeCl excimer laser at various fluence *F*. The solid lines indicated the experimentally measured temperature (Exp), while the broken lines the numerically simulated temperature (Sim). A typical laser pulse shape is also shown as a reference.

Acknowledgment: This work was partly supported by the Grant-in-Aid for Young Scientists (B) (24760608) from the Japan Society for the Promotion of Science (JSPS).

References: 1) K. Shinoda, T. Nakajima, T. Tsuchiya, Appl. Phys. B 113 (2013) 479-484; 2) K. Shinoda, T. Nakajima, T. Tsuchiya, Appl. Surf. Sci. DOI: 10.1016/j.apsusc.2013.12.101, in press.