Influence of Oxygen and Nitrogen Background Gas in Femtosecond Pulsed Laser Deposition of Nd:YAG Laser Crystal

Lean Dasallas[1], Joy Kristelle De Mata[1], Arriane Lacaba[2,3], Wilson Garcia[3]

[1]Material Science and Engineering Program, University of the Philippines

[2]Maxim Philippines Operating Company, [3]National Institute of Physics, University of the Philippines

E-mail: ldasallas@msep.upd.edu.ph

Introduction and Methodology

Pulsed laser deposition (PLD) is a novel way of depositing thin films. Obtaining high quality thin films is usually done by optimizing growth parameters such as background gas. Most investigations on the effects of background gas in PLD involve the use of nanosecond (ns) pulsed laser as excitation source. Recently, the use of femtosecond (fs) pulsed laser as excitation source in PLD are being explored. In general, particulates are minimized when fs pulsed laser excitation is used, making parametric investigation more manageable.

In this work, we examined the effects of nitrogen and oxygen as background gases in the fs PLD of Nd:YAG laser crystal. Deposition was carried out using fs Ti:Sa pulsed laser with λ = 800 nm, 80 MHz repetition rate and ~ 700 mW average power. Reflectivity and FTIR was determined to characterize the thin films.

Results and Discussion

Figure 1a shows the reflectivity plot of the NdYAG thin film deposited using oxygen and nitrogen background gas. We can readily observe the lowered reflectivity of the thin film deposited using oxygen background gas, which we believe is due to the enhanced absorption of the incident light. The presence of oxygen as background improved the chemical composition of the thin film as compared to nitrogen gas. The optical bandgap of the film deposited in oxygen background has been calculated to be 1.409 eV, close to the bulk NdYAG crystal.

However, the corresponding FTIR spectra reveals an almost similar behavior. Both films have almost flat feature from 4000 cm^{-1} – 2000 cm^{-1} and a dip in the 1100 cm^{-1} region. NdYAG film on nitrogen background gas have minor peaks at ~ 3200 cm^{-1} and 2800 cm^{-1}. These results revealed slight dependency of the molecular vibrations in the background gas. Nevertheless, these preliminary results indicate the crucial role of background gas in PLD even when using fs pulsed laser, which can be explained in terms of Gibbs free energy of the thin films given by the equation

$$\Delta G_V = -\frac{kT}{\Omega}\ln\left(\frac{P}{P_e}\right).$$

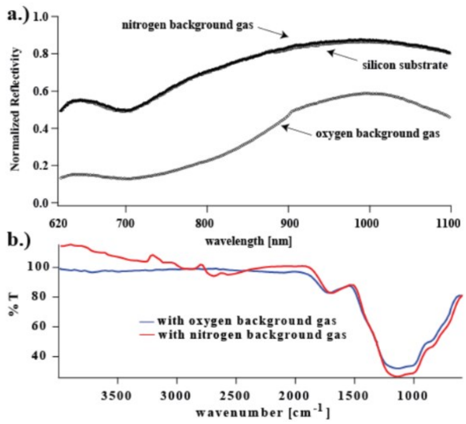

Figure 1. Normalized reflectivity of thin films deposited with oxygen and nitrogen background gas. B.) FTIR spectra of thin films deposited with oxygen and nitrogen background gas

Acknowledgement

This research is funded by Natural Science Research Institute under the project title “Investigating the influence of background gases in the pulsed laser deposition of laser crystals with femtosecond pulsed laser as excitation source”

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