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Pulsed Laser Deposition of Nd:YAG using Femtosecond Laser

Lean L. Dasallas[1], Arriane P. Lacaba, Jeffrey C. de Vero, Wilson O. Garcia
Optical Society of America
E-mail: ldasallas@nip.upd.edu.ph

1. Introduction and Methodology

Neodymium doped yttrium aluminum garnet (Nd:YAG) is a well known host crystal for the production of coherent pulses of light for laser operation [1]. These inherent properties of the Nd:YAG makes it suitable for optoelectronics such as waveguide and miniature laser in thin film form [2,3].

Pulsed laser deposition (PLD) is a novel way of fabricating thin films especially in the preparation of multi-elemental component material like Nd:YAG. PLD is known for is flexibility obtaining thin films with well controlled composition [4]. It has been customary to use pulsed lasers in *nanosecond (ns)* duration in ultraviolet wavelength having produced epitaxial thin films [5]. In recent there's a growing interest in using *femtosecond (fs)* pulsed lasers for PLD.

The *fs* laser produces short pulses of highly energetic photons shorter than the electron-lattice interaction time and shorter propagation of heat on the target surface thereby reducing the thermal damage on the target. This has considerably lead to fewer spheroidal particles on film surface commonly observed in thin films produced by *ns* based PLD [6].

In this work, we investigated the properties of Nd:YAG thin film on Si(100) substrate using femtosecond laser operating at λ= 785 nm having a pulse duration of 100 *fs* and repetition rate of 80 MHz.

The crystallinity of the deposited film was investigated using X-ray diffraction while the surface morphology was investigated using Scanning Electron Microscopy.

2. Results and Discussion

Figure 1 shows the x-ray diffraction spectra of the Nd:YAG film on Si (100) substrate deposited at 2 hrs deposition time and 3 cm target to substrate distance. For comparison the XRD spectra of the Nd:YAG target and substrate is also shown in the figure. It can be observed that the film is strongly oriented only along the (321) reflection of the Nd:YAG crystal having fullwidth at half maximum of about 0.28 degrees.

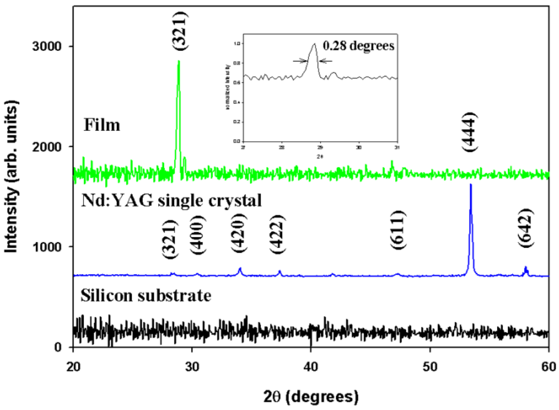

Figure 1. XRD spectra of Nd:YAG film deposited at 3 cm target to substrate distance, 10-6 mbar deposition pressure and 2 hrs deposition time.

Scanning electron microscope image of the film is also shown in figure 2. The surface is composed granular particulates with minimal aggregation.

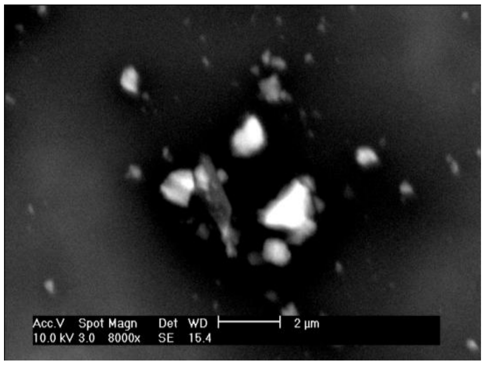

Figure 2. Surface morphology of film deposited at 3 cm target to substrate distance, 10^{-6} mbar deposition pressure and 2 hrs deposition time.

The observed properties of the film show the capability of *fs* laser as a viable option for pulsed laser deposition. Improvements on the observed properties can now be implemented by considering other PLD parameters such as substrate heat treatment and introduction of background gas.

3. Conclusions

Pulsed laser deposition of Nd:YAG crystal has been performed using femtosecond laser as an excitation source. (321) growth orientation has been observed in the XRD spectra and the surface reveals random distribution of the particles. Improvement of the film quality by modification of existing PLD parameters are currently underway to obtain better quality films.

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