# GARNET CRYSTAL GROWTH BY FEMTOSECOND PULSED LASER DEPOSITION

Mark. S. B. Darby, Timothy C. May-Smith, Robert W. Eason
*Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, United Kingdom*

Tony Donnelly and James. G. Lunney
*Physics Department, Trinity College Dublin, Dublin 2, Ireland*

Keith. D. Rogers
*Cranfield University, Shrivenham, Swindon , SN6 8LA, United Kingdom*

e-mail*:* msbd@orc.soton.ac.uk

We have demonstrated heteroepitaxial growth of Nd:$Gd_3Ga_5O_{12}$ (Nd:GGG) on $Y_3Al_5O_{12}$ (YAG) by femtosecond pulsed laser deposition (PLD). A Ti:sapphire laser was used at a wavelength of 800 nm and pulse length of 130 fs, operating at a repetition rate of 1 kHz. X-ray diffraction analysis shows that epitaxial growth has occurred (figure 1). The effects of various growth conditions have been investigated including fluence, spot-size, target-substrate distance and substrate temperature. The effect of these conditions on crystallinity and optimum conditions will be discussed. An investigation of the plume characteristics using the Langmuir probe technique has revealed that plasmas produced by femtosecond ablation have ions with considerably higher velocities, ~ seven times faster than for nanosecond PLD of the same target material. In our study of growth parameters, we have found that higher ambient gas pressures are required to moderate the ion velocities in the femtosecond-ablated plume to achieve velocities more closely related to the optimum nanosecond conditions. Atomic force microscopy reveals that even at the optimum conditions films suffer from comparatively high surface roughness, with RMS roughness values of 60 – 70 nm. This level of roughness for films grown by femtosecond PLD could be explained by the presence of highly energetic species formed during femtosecond ablation, which generate defects and thus disturb the smooth growth of crystallites that takes place under the comparatively more controlled nanosecond regime. In this talk, we will discuss the effect on thin film growth of all parameters varied, and conclude that the window for optimum growth is far narrower than for nanosecond growth.

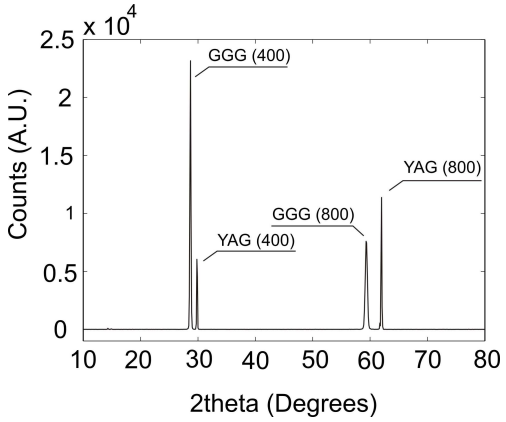


**Figure 1:** X-ray diffraction spectrum of a Nd:GGG film (~500nm thick) deposition by femtosecond PLD.