PHYSICAL AND STRUCTURAL PROPERTIES OF Nd:YAG CRYSTAL GROWTH BY CZOCHRALSKI METHOD

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Thesis submitted in fulfilment of the
requirements for the degree of
Master of Science (Physics)

Faculty of Science
Universiti Teknologi Malaysia

AUGUST 2012

Especially dedicated:

To my ever encouraging, supportive, and devoted

Family and Friends

Thank you for being a huge inspiration for my success

ACKNOWLEDGEMENT

All praise to Allah Almighty, for giving me strength and courage to carriedout this study. I would like to express my deepest and sincerest gratitude to my supervisor Assoc. Prof. Dr. Md Supar Rohani for the guidance, criticism, encouragement and giving the opportunity to work on this fascinating subject. I would also like to acknowledge Dr. Zuhairi Ibrahim, Prof. Dr. Md Rahim Sahar for their criticisms and advices.

Many individuals both within the formal framework of collaboration, and outside of it, have been there when scientific and moral support has been needed. I thank you all.

Finally, I want to thank my family and my entire colleague for their kindness and encouragements.

The value of this thesis remains to be judged by those who read it. At least for me personally, the work has been a rewarding experience.

ABSTRACT

Neodymium doped Yttrium Aluminium Garnet, Nd:YAG crystal with nominal dopant concentration of 1.4 at. % was successfully grown by Czochralski technique equipped with an Automatic Diameter Control – Crystal Growth System (ADC-CGS). Correlation between dopant concentrations with the length of crystal boule in relation with physical and structural properties was studied. It was found that the crystal was partially transparent with some visible macroscopic defects such as cracks, gas pores, and inclusion. Its physical appearance is strongly affected by heat zone design. From EDX analysis, it was found that the doping concentration of Nd^{3+} ion increased as the crystal boule became longer than its initial pulling point. From the top to the bottom of Nd:YAG crystal boule, the concentration of Nd^{3+} changed from 0.13 at. % to 0.65 at. %. The density of the samples was determined by Archimedes method which showed an increasing trend of density with the crystal length which was found to be in the range of 4.5344 ± 0.0153 gcm^{-3} to 4.5628 ± 0.0114 gcm^{-3}. It was also discovered that Vickers hardness increased with increasing dopant concentration which was from 1590 Hv to 1776 Hv. Raman spectrum was obtained in the range of 100 cm^{-1} – 1000 cm^{-1}. From the spectra, the intensity was found to vary and shifting occured in the band due to the Nd^{3+} dopant concentration. Meanwhile, the IR spectra shows absorption occurring around 2000 cm^{-1} to 4500 cm^{-1}. Absorption tends to be greater with increasing dopant concentration. Furthermore, the effect of melts level to the growth process has also been studied and it is suggested that the crucible should be lifted up according to the level of the melts drop during growing process to maintain the temperature gradient of the hot zone.

ABSTRAK

Hablur Yttrium Aluminium Garnet didop Neodimium (Nd:YAG),dengan nilai nominal kepekatan dopan sebanyak 1.4 at. % telah berjaya ditumbuhkan dengan kaedah Czochralski yang dilengkapi dengan sistem Pengawalan Diameter Automatik – Sistem Pertumbuhan Hablur (ADC-CGS). Perkaitan antara kepekatan dopan dengan kedudukan panjang tongkol hablur dari segi sifat-sifat fizikal dan struktur telah dikaji. Didapati bahawa hablur adalah separa lutsinar dengan sedikit kecacatan makroskopik yang boleh dilihat seperti retak, gelembung dan rangkuman bendasing. Bentuk fizikalnya sangat dipengaruhi oleh rekabentuk zon haba. Berasaskan analisis EDX, kepekatan ion dopan Nd^{3+} meningkat apabila tongkol hablur bertambah panjang dari titik permulaan penarikannnya. Dari bahagian atas ke bawah tongkol hablur Nd:YAG, berlaku perubahan kepekatan Nd^{3+} dari 0.13 at. % kepada 0.65 at. %. Ketumpatan sampel telah ditentukan melalui kaedah Archimedes dan menunjukkan arah aliran yang meningkat dengan pemanjangan tongkol hablur dan berada dalam julat 4.5344±0.0153 gcm^{-3} hingga 4.5628±0.0114 gcm^{-3}. Didapati juga kekerasan Vickers hablur meningkat dengan peningkatan kepekatan dopan iaitu dari 1590 Hv ke 1776 Hv. Spektrum Raman telah diukur dalam lingkungan 100 cm^{-1} – 1000 cm^{-1}. Dari spektra tersebut, keamatan berubah dan anjakan berlaku dalam jalur spektra akibat kepekatan ion Nd^{3+}. Sementara itu, spektra IR menunjukkan penyerapan berlaku sekitar 2000 cm^{-1} hingga 4500 cm^{-1}. Penyerapan cenderung menjadi lebih besar dengan peningkatan dopan. Tambahan pula, kesan paras leburan untuk proses pertumbuhan juga turut dikaji dan disarankan bahawa krusibel patut dinaikkan mengikut aras penurunan leburan semasa proses pertumbuhan untuk mengekalkan kecerunan suhu zon panas.