Studi pengaruh ukuran partikel dan proses aktivasi mekanik pada sintesis Yttrium Aluminium Garnet (YAG) sebagai material Solid-State Laser = The effect of particle size and mechanical activation process in Yttrium Aluminum Garnet (YAG) synthesis as solid-state laser materials

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Abstrak

Gangguan penglihatan merupakan permasalahan yang sering ditemui di masyarakat dimana dapat disembuhkan total melalui operasi menggunakan laser. Sumber laser yang sering digunakan bersumber dari keramik transparan dengan material YAG. Namun, sintesis dari material YAG memerlukan temperatur 1600oC yang mana memerlukan energi yang tinggi. Sehingga, dalam penelitian ini, akan dikaji pengaruh ukuran partikel bahan awal dan proses aktivasi mekanik terhadap proses sintesis yttrium aluminium garnet (YAG). Studi yang dilakukan meliputi karakterisasi bahan awal secara komprehensif, melihat pengaruh perbedaan bahan awal pada saat proses pencampuran, serta mengkaji sifat termal sampel dengan ukuran bahan awal yang berbeda dan proses pencampuran yang berbeda. Karakterisasi yang dilakukan meliputi particle size analyzer, x-ray diffraction, x-ray fluorescence, scanning electron microscope, dan thermogravimetry analysis. Bahan awal yang digunakan yaitu alumina dengan 2 ukuran berbeda yang memiliki kemurnian rendah dan yttria dengan kemurnian tinggi. Proses pencampuran manual dan milling dapat menghasilkan perbedaan yang signifikan pada nilai ukuran partikel dan ukuran kristalit setelah proses pencampuran. Akan tetapi, perbedaan ukuran bahan awal yang dicampur tidak berpengaruh terhadap hasil pencampuran. Analisis sifat termal menunjukkan perbedaan antara pencampuran manual dengan proses milling, di mana temperatur terjadinya reaksi setelah melaui proses milling menjadi lebih rendah. Di samping itu, hasil XRD pada pada sampel dengan proses pencampuran berbeda menunjukkan perbedaan yang sangat signifikan. Pada sampel pencampuran manual, hanya terbentuk fasa yttrium aluminium monoklinik (YAM) dengan sisa yttria dan alumina yang tidak bereaksi pada temperatur 1100oC. Di samping itu, milling menggunakan media alumina, juga hanya membentuk fasa yttrium aluminium perovskit (YAP) dengan fasa minor YAM dan alumina pada saat dipanaskan pada temperatur 1100oC. Di sisi lain, dengan milling menggunakan media stainless steel, terbentuk fasa YAG pada temperatur 1100oC dengan pengotor berupa alumina yang tidak bereaksi. Rute reaksi sintesis YAG pada penelitian ini berbeda dengan umumnya di mana terbentuk fasa sekunder YFeO3 terlebih dahulu, kemudian bereaksi lebih lanjut dan membentuk YAG. Berdasarkan hasil yang didapatkan, ukuran partikel tidak memiliki pengaruh signifikan terhadap pembentukan fasa YAG. Di sisi lain, proses milling menggunakan media stainless steel secara signifikan dapat mengurangi temperatur sintesis dari YAG dari 1600oC menjadi 1100oC. Dengan adanya penurunan temperatur sintesis ini, diharapkan pengembangan material YAG sebagai solid-state laser semakin berkembang dan dapat digunakan pada bidang medis.

......Visual disturbance problem is occurred in the society frequently. This illness can be completely cured through surgery using laser which usually used are made of transparent ceramic with YAG material. However, the synthesis of YAG material requires a temperature of 1600oC which requires high energy. So, in this research, the effect of particle size of raw material and mechanical activation process on the synthesis of yttrium aluminum garnet (YAG) had been studied. The studies were consisted about three part, there are: comprehensive characterization of raw materials, observe the effect of mixing and milling process to the materials, as well as investigate the thermal properties of the samples with different sizes of raw materials and different methods. Therefore, particle size analyzer, x-ray diffraction, x-ray fluorescence, scanning electron microscopy, and thermogravimetric analysis were used as characterization instruments. The obtained data showed that the raw materials used were alumina with two different sizes which have low purity and yttria with high purity. Moreover, manual mixing and milling processes could produce significant differences in particle size and crystallite size after the process. However, the difference in the size of the raw material mixed did not affect the mixing result. Then, analysis of thermal properties showed the difference between manual mixing and the milling process, where the reaction temperature of YAG after the milling process became lower. In addition, the XRD results on samples with different mixing processes showed a very significant difference which in the manual mixed sample, only monoclinic yttrium aluminum (YAM) was formed with the remaining unreacted yttria and alumina at 1100oC. In addition, milling using alumina media only formed yttrium aluminum perovskite (YAP) phase with YAM and alumina minor phases when heated at 1100oC. On the other hand, when stainless steel media was used, a YAG phase was formed at a temperature of 1100oC with an impurity in the form of unreacted alumina. The reaction route for YAG synthesis in this study was different from that in general where the secondary phase of YFeO3 was formed first. Then, this secondary phase reacted further with the remaining alumina and finally formed YAG phase. Based on the results obtained, the particle size did not have a significant effect on the formation of the YAG phase. But, the milling process by using stainless steel media could significantly reduce the synthesis temperature of YAG from 1600oC to 1100oC. Therefore, this synthesis temperature decrease hopefully will accelerate the development of YAG materials as solid-state lasers so that it can be used in the medical field.