

## Sintesa dan struktur kristal keramik garnet $Y_3Fe_{5-5x}Al_{5x}O_{12}$

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### Abstrak

The effect of Fe substitution on Al of garnet ceramic with chemical formula  $Y_3Fe_{5-5x}Al_{5x}O_{12}$ , where x (synthesis) of 0, 0.05, 0.15, and 0.25, has been investigated. Sample in this study were synthesized using wet oxydation method, Hot Kerosene Drying (HKD). All constituents were used in liquid form from  $YCl_3 \cdot 6H_2O$ ,  $AlCl_3$ , and  $Fe_2O_3$  and HCl, which were reagents with purity better than 99%. Thermal analysis (DTA) was used to investigate calcination and sintering temperature. The resultant powders were calcined at  $1250^\circ C$  and sintered  $1350^\circ C$  and  $1400^\circ C$ . The X-ray diffractogram, which were obtained at room temperature, were refined using crystallographic software package GSAS. The samples contain at least 85% garnet phase with the remaining  $Fe_2O_3$  impurity phase. In those garnet phases, 0 atom slightly shift. As a concentration increases theoretical densities decreases. For increasing x (synthesis) above, the theoretical densities and unit cell volume, respectively are of 5.148  $gr/cm^3$ , 4.951  $gr/cm^3$ , 4.946  $gr/cm^3$ , 4.918  $gr/cm^3$  and  $1.890 \times 10^{-21} cm^3$ ,  $1.885 \times 10^{-21} cm^3$ ,  $1.874 \times 10^{-21} cm^3$ ,  $1.856 \times 10^{-21} cm^3$  for the sample sintered at  $1350^\circ C$ . Similarly, at  $1400^\circ C$ , the theoretical densities and unit cell volume, respectively, are of 5.136  $gr/cm^3$ , 5.100  $gr/cm^3$ , 5.021  $gr/cm^3$ , and  $1.891 \times 10^{-21} cm^3$ ,  $1.885 \times 10^{-21} cm^3$ ,  $1.875 \times 10^{-21} cm^3$  without x (synthesis) of 0.25. The formula of resultant garnets, respectively, are of  $Y_3Fe_{4.88}O_{12}$ ,  $Y_3Fe_{3.77}Al_{1.23}O_{12}$ ,  $Y_3Fe_{3.61}Al_{1.39}O_{12}$ , and  $Y_3Fe_{3.25}Al_{1.75}O_{12}$  for the samples sintered at  $1350^\circ C$ . Similarly, at  $1400^\circ C$ , The formula of resultant garnets, respectively, are of  $Y_3Fe_{4.33}O_{12}$ ,  $Y_3Fe_{4.51}Al_{0.89}O_{12}$ ,  $Y_3Fe_3Al_2O_{12}$ . Based on macroscopic measurements, the average bulk density and porosity respectively, are of 3.458  $gr/cm^3$  and 27.32%, which confirms the X-ray diffraction (microscopic) measurement.

Telah dilakukan penelitian terhadap keramik garnet dengan rumus kimia  $Y_3Fe_{5-5x}Al_{5x}O_{12}$ . Nilai sintesis x adalah 0; 0,05; 0,15 dan 0,25. Sintesa dilakukan dengan metoda oksidasi basah, yaitu Hot Kerosene Drying (HKD). Bahan dasar yang digunakan adalah  $YCl_3 \cdot 6H_2O$ ,  $AlCl_3$ ,  $Fe_2O_3$ , dan HCl dengan kemurnian diatas  $\pm 99\%$ . Setelah sintesa dilakukan analisa termal (DTA) untuk mengetahui temperatur kalsinasi dan temperatur sintering: Sampel dikalsinasi pada pada temperatur  $1250^\circ C$  dan disintering pada temperatur  $1350^\circ C$  dan  $1400^\circ C$ . Analisa difraksi dilakukan pada masing-masing sampel dan diolah dengan perangkat lunak GSAS. Didapatkan persentase garnet yang terbentuk diatas 85% untuk seluruh sampel, dengan fasa pengotor adalah  $Fe_2O_3$ . Posisi atom-atom penyusun garnet hasil sampel yang disintesa menunjukkan tidak ada perubahan, kecuali pada atom 0 ada sedikit pergeseran posisi atom. Densitas teoritis menurun dengan semakin tingginya konsentrasi Al pada garnet. Dari harga nominal x diatas didapatkan densitas teoritis dan volume per unit selnya berturut-turut: 5,148  $gr/cm^3$ , 4,951  $gr/cm^3$ , 4,946  $gr/cm^3$ , 4,918  $gr/cm^3$  dan  $1,890 \times 10^{-21} cm^3$ ,  $1,885 \times 10^{-21} cm^3$ ,  $1,874 \times 10^{-21} cm^3$ ,  $1,856 \times 10^{-21} cm^3$  untuk temperatur sintering  $1350^\circ C$  serta 5,136 Tice, 5,100  $gr/cm^3$ , 5,021  $gr/cm^3$ , dan  $1,891 \times 10^{-21} cm^3$ ,  $1,885 \times 10^{-21} cm^3$ ,  $1,875 \times 10^{-21} cm^3$  untuk temperatur  $1400^\circ C$  (tanpa nilai sintesis  $x=0,25$ ). Sedangkan rumus kimia garnet yang terbentuk berturut-turut adalah  $Y_3Fe_{4,88}O_{12}$ ,  $Y_3Fe_{3,77}Al_{1,23}O_{12}$ ,  $Y_3Fe_{3,61}Al_{1,39}O_{12}$ ,  $Y_3Fe_{3,25}Al_{1,75}O_{12}$  untuk temperatur sintering  $1350^\circ C$  dan  $Y_3Fe_{4,88}O_{12}$ ,  $Y_3Fe_{4,51}Al_{0,89}O_{12}$ ,

Y<sub>3</sub>Fe<sub>3</sub>A<sub>12</sub>O<sub>12</sub> untuk temperatur sintering 1400°C. Dihitung pula secara makroskopik densitas bulk dan porositas, dengan harga rata-rata 3,458 gr/cm<sup>3</sup> untuk densitas bulk serta 27,32% untuk porositas.