

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 $Y_3Fe_{4,88}O_{12}$, $Y_3Fe_{4,51}Al_{0,89}O_{12}$,

Y₃Fe₃A₁₂O₁₂ untuk temperatur sintering 1400°C. Dihitung pula secara makroskopik densitas bulk dan porositas, dengan harga rata-rata 3,458 gr/cm³ untuk densitas bulk serta 27,32% untuk porositas.