PREPARATION AND CHARAKTERIZATION OF YTTRIUM-ALUMINIUM GARNET ($Y_3Al_5O_{12}$)

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Abstract. *This work deals with the preparation of powders and transparent yttrium aluminium garnet ($Y_3Al_5O_{12}$ - YAG) from nanopowders. Stoichiometric amounts of nanocrystalline Al_2O_3 and Y_2O_3 were mixed and chemically pretreated using different basic agents and using ultrasonic bath. Resulting mixture was dried, pressed and heated up to 1750°C. Final material was characterized by X-ray diffraction, DTA and optical and electron microscopy.*

1. INTRODUCTION

Yttrium aluminium garnet ($Y_3Al_5O_{12}$ - YAG) is the material, which is often used for the production of scintilation detektors and solid state lasers. In industry, it is produced by monocrystal drawing from melting (Czochralski method) and consecutive mechanical working (cutting, grinding, and polishing). However, this production process is very difficult due to high temperature of melting mixture (melting point of YAG = 1970°C) and need for resisting noble metal crucibles, which give the very high production costs.

The effort of research teams is now oriented in the direction of decreasing of production costs, i.e. decreasing of temperature needed for YAG preparation. The most simple and the cheapest method seems to be the preparation of transparent YAG ceramics from Al_2O_3 and Y_2O_3 nanopowders [1].

2. EXPERIMENTAL

The respective stoichiometric amounts of Al_2O_3 and Y_2O_3 were weighed out in beaker. Two basic agents were used for chemical pretreatment - 10% solution of tetramethylamonium hydroxide (TMAH) and amonium hydroxide respectively. In order to improve the transparency, the small amount of tetraethoxysilane (TEOS) (molar ratio YAG:SiO_2 = 1000:1) was added to this mixture. The suspensions were treated in ultrasonic bath with high energetic ultrasonic power of about 50 W. Then, the samples were dried and ther-

mally pretreated at 800°C. Resulting powder was pressed using cold or heat isostatic pressing and then heat treated in furnace at 1750°C.

Final samples were tested for transparency and characterized by X-ray diffraction, DTA and electron microscopy. X-ray patterns were measured at ambient temperature using a diffractometers Phillips and Bruker. Two type of scanning electron microscopes were used: electron microscope PHILIPS XL 30 CP for orientation observation and AQUASEM - (Tescan) - low-vacuum scanning electron microscope for detail observation of the samples.

3. RESULT AND DISCUSSION

All samples treated at maximal temperature of 1750°C prepared using both TMAH and amonia contained transparent crystals of 2 μm in diameter with defects. These transparent crystals were embedded in the YAG with poor crystallinity and for this reason the entire samples were not transparent.

The powder diffraction pattern revealed that the only phase present in the sample seems to be YAG (Figure 1). But the detailed view shows that the samples contained also some small amount of non-reacted alumina (inset in Figure 1).

Scanning electron microscope (SEM) images revealed that the structure contains the crystals of the size of several microns (Figure 2). These crystals are directly connected having gap smaller the 10 nm. This is favourable findings, because this size of pores does not raise the light diffusion and that samples are then transparent. But, unfortunately, at the same time we can observe the greater pores of the size of microns that have spurious effect to the sample transparency.

SEM images revealed that the main reason of the non-transparent aspect is porosity of the sample. This porosity can be due to the water adsorbed on the nanopowders surface or insufficient pressure during the isostatic pressing.

4. CONCLUSION

Small transparent crystals of the size of 2 μm were prepared using nanopowder Al_2O_3 and Y_2O_3, but these crystals were embedded in non-transparent phase. Other experiments with vacuum and heat pretreatment and using higher isostatic pressure must be done in order to avoid the large porosity and prepare transparent samples.

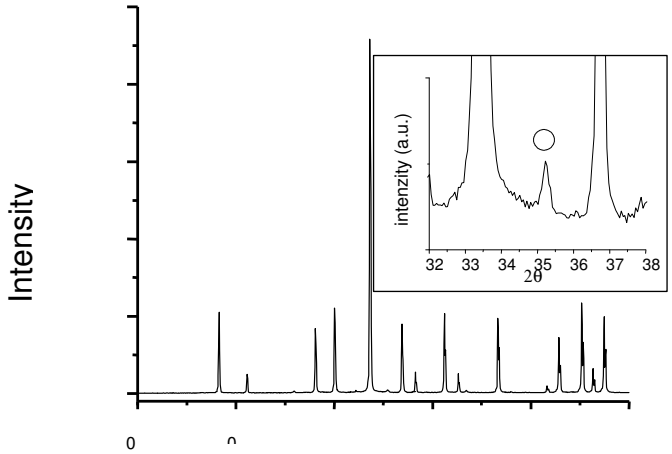

Figure 1. XRD pattern of the 1750°C heat treated sample. Inset represents detailed view (circle denote the most intensive peak of Al_2O_3).

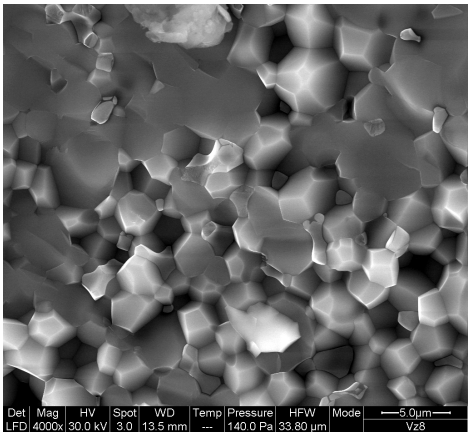

Figure 2. SEM image of the 1750°C heat treated sample.

5. REFERENCES

1. Ikesue Akio, Japon patent No. JP 04-091156, 1999.