INVESTIGATION OF THE WETTABILITY OF Al_2O_3 - Y_2O_3 STOICHIOMETRIC COMPOUNDS ON AlN

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INTRODUCTION:

Aluminum nitride (AlN) is one of the candidate materials for use in electronic packaging and engineering ceramics [1]. It offers both higher thermal conductivity and superior electrical insulating properties when compared with aluminum oxide (Al_2O_3) [2]. Y_2O_3 is the best additive for AlN sintering [1,3], and it has been hypothesized that aluminum nitride densifies by a transient liquid phase mechanism, where the surface oxide, Al_2O_3, reacts with the oxide additive, Y_2O_3, to form Y-Al-O-N liquid that promotes particle rearrangement and densification [1,4,5]. So, for further development of the AlN ceramic materials studying the interaction of AlN with Al_2O_3-Y_2O_3 compounds is becoming essential. The wetting of a solid surface by a liquid depends on the dihedral angle which is given by the energy ratio between the grain boundaries (γ_{ss}) and the liquid-solid surface (γ_{sl}). A large dihedral angle gives poor wetting of the inerface. Wetting is often associated with a chemical reaction on the surface, and hence aided by the solubility of the solid in the liquid, formation of intermediate compounds and interdiffusion [6].

EXPERIMENTAL PROCEDURE:

Substrates of pure AlN were fabricated by hot pressing (1800°C, 30MPa for 30min), using Aluminum Nitride powder, grade F, supplied by Tokuyama Soda, Japan. The powder contains: <0.9 wt% of oxygen, <400ppm of carbon and trace amount of other impurities (<60 ppm of Ca, < 10 ppm of Fe, <15 ppm of Si). The powder has a mean particle size of ~0.3μm. and a specific surface area of 3.3 m^2/g. After pressing, AlN surfaces were ground and polished with SiC paper and diamond paste (9μm). The substrates were finally polished with colloidal silica suspension (0.05μm).

The starting materials for preparation of these compounds were stoichiometric mixtures of the following powders:

1. Aluminum oxide (A16-SG, Alcoa Industrial Chemical Division) with 99.7% purity.
2. Yttrium Oxide, Grade 5600, supplied by Union Molycorp, U.S.A. with 99.99% purity. The Y_2O_3 powder had a mean agglomerate size of 1.8 μm and a specific surface area of 33 m^2/g.

The premixed stoichiometric compositions were ball milled for 1 h using alumina media and water, the resultant slurry was dried then seived. This powder was mixed with water and 8% of hydroxypropyl cellulose as a plasticizer, the mixture was extruded into 2.5 mm diameter rods. These rods were dried in air for 24 h, then sintered in air for 2 h at 1500°C. The required droplets were formed by melting these rods at 2200°C using an oxyacetylene torch. The phase development was investigated using X-ray powder diffraction at different stages and the stability of these phases were analyzed by DTA. $Y_3Al_5O_{12}$ (YAG), $YAlO_3$ (YAP) and $Y_4Al_2O_9$ (YAM) droplets were individually placed on the top of the polished AlN surface in order to conduct the wettability test at different heating and cooling rates, soaking temperatures and atmospheres.

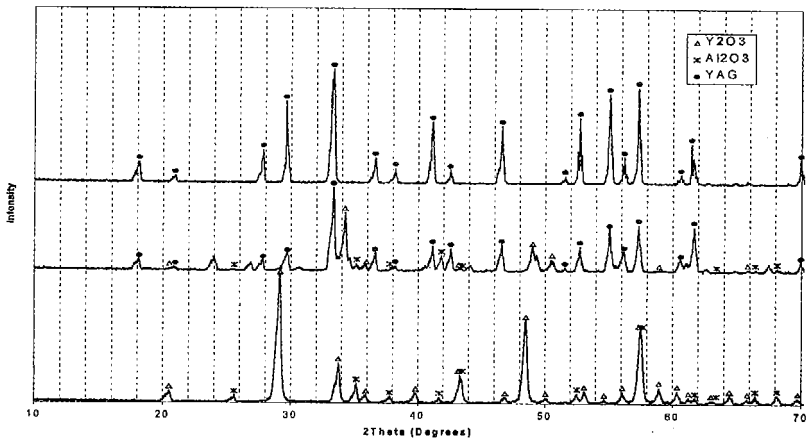

Figure 1 XRD patterns of different stages of producing YAG.

RESULTS

X-ray diffractograms for YAG composition at different stages of production are shown in Figure (1). Pattern (a) is for the mixed powder with the required ratio of 62.5 mol% Al_2O_3 and 37.5 mol% Y_2O_3. (b) is for the rods after sintering at 1500°C for 2 h. (c) is for the solidified YAG after melting, indicating the presence of the pure YAG compound without residuals. Pattern (b) shows peaks related to Y_2O_3 and Al_2O_3, as well as, YAG. This indicates that nucleation and formation of YAG takes place at this temperature for this time. However, the reaction is incomplete.

Visual inspection of the samples showed that there is a difference in the wetting behavior with changing the working conditions for the different compounds. The table below shows the design of the experiments to investigate the wettability.

Table 1 The design of the wettability experiments.

Temperature range	Atmosphere	Heating rate	Cooling rate
1800 to 1975°C	Argon or Nitrogen	1 to 10°C/min	1 to 10°C/min

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