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# The structural properties of alumina prepared using a modified slip-casting method

**Sang-Chul Lee, Seung-Hwan Lee and Young-Hie Lee***
*Dept. of Electronics Materials Engineering, Kwangwoon University, 447-1 Wolgyedong, Nowongu, Seoul 139-701, Korea*

**The structural properties of green and sintered bodies prepared using a modified slip casing method were investigated as a function of the solid loading and air pressure. The green density increased with an increase in the solid loading. The green density was not changed but the volume of the green body increased an increase in the air pressure. There were no microcracks or pores in the green body manufactured by the modified forming method. Also, the sintered body had a compact microstructure.**

**Key word: Alumina, Air pressure, Forming body, Relative density.**

## Introduction

The growth of the display industry has created a demand for large area LCDs, PDPs and monitors. To increase their size and improve their productivity, the display industry invests heavily every year to expand their manufacturing base. Thus, the display equipment industry attempts to improve the manufacture of the equipment by performing the transfer and deposition processes on large size glass substrates. However, the ceramic parts which are used as components in the manufacture of this equipment are not easy to form with a large size by the existing methods. Ceramic parts, therefore, are used to manufacture equipment using the division assembly method. This division assembly method has an advantage in terms of the fabrication of large size components, but requires the use of various complementary devices to overcome the problem of the weight of the large size glass substrate. Nowadays, LCD equipment sometimes requires ceramic parts with a size of 2 m or more and these are difficult to manufacture by the existing slip-casting and press method [1]. Much research has been done into materials which are suitable for large area processing using the gel-casting method. However, it is difficult to produce commercial products by this method, because of the increasing amount of porosity and cracks in the materials with an increase in the area. In this study, we investigated the forming properties of alumina with an air pressure and gypsum mold which are an improved existing gypsum mold and slip-casting method. It is difficult to form thick films using the proposed method, but it is easy to form large area films due to moisture absorption along the thickness direction.

*Corresponding author:
Tel : +82-2-940-5164
Fax: +82-2-915-8084
E-mail: yhlee@kw.ac.kr

## Experimental

The alumina slurries were prepared with commercial alumina 160SG (Showadenko), PVA 205 and D-305. The solid loadings of the slurries were 30 vol%, 35 vol% and 40 vol%. The slurry was mixed and ground by ball-milling for 5 h. The slurry prepared was molded with gypsum and plastic molds. The molding equipment allowed the injection of air at a predetermined pressure, as shown in Fig. 1. A SUS plate, pin and nut were used in the molding equipment to maintain the air pressure. The gypsum and plastic molds with diameters of 100 mm were positioned on the bottom side, so that the slurry was molded under the air pressure. The green body was manufactured with different air pressures of 2, 3 and 4 gf/cm$^2$. The manufactured green bodies were sintered at 1650 °C for 2 h. The viscosities of the slurries were measured for the purpose of determining

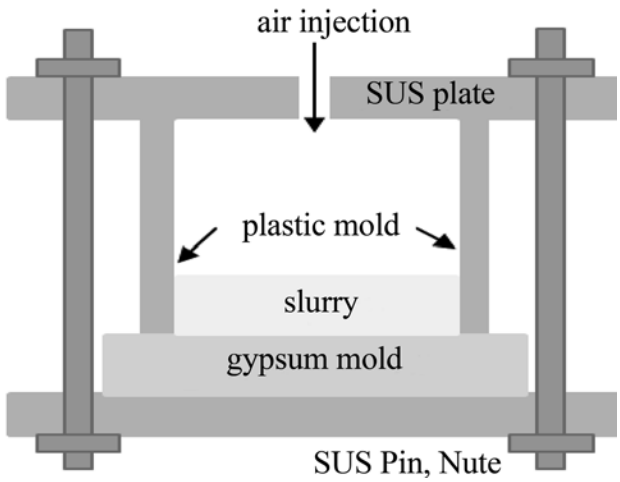


**Fig. 1.** Schematic of the forming mold with the application of air pressure.

the structural properties of the green body. Also, a microstructural analysis was performed for the green body after annealing at 800 $^oC$ for 1 h, where the grains do not undergo a solid state reaction. The bulk densities of the annealed green bodies were measured as a function of the air pressure and solid loading. The microstructure of the sintered bodies was analyzed after sintering.

## Results and Discussion

Fig. 2 shows the flow curves of the alumina slurries prepared with different solid loadings. The viscosity increased with an increase in the solid loading. The measurements were performed with a viscometer (DV- Ultra). The viscosity was the same at shear rates of 30 and 35 vol%, but decreased when the shear rate was 40 vol%. In the case of shear rates of 30 and 35 vol%, the viscosity remained constant because of the low solid loading, where the alumina particles had sufficient space in the slurry. However, the decrease in the viscosity at a shear rate of 40 vol% was caused by the high solid loading.

The bulk densities calculated from the measured volumes and weights of the annealed green bodies are depicted in Fig. 3. The bulk densities of the green bodies fabricated using 30 and 35 vol% solid loading in the slurry were similar, but the green body manufactured using 40 vol% solid loading in the slurry had a relatively high bulk density. The bulk density increased with increasing solid loading, as in the case of the slip-casting method. This is caused by the use of a gypsum mold. Also, there was no variation in the bulk density with the air pressure. The thickness of the green body increased with an increase in the air pressure. The reason for this was the direction of the air pressure was the same on the moisture absorption of the gypsum mold which increases the forming speed of the green body.

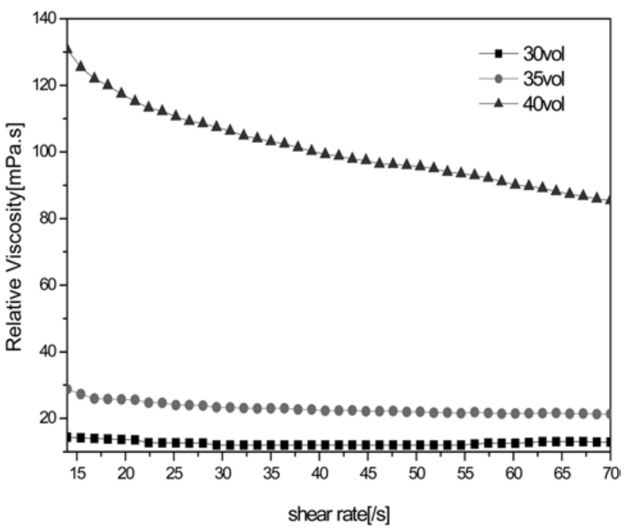


**Fig. 2.** Variation of the viscosity of the alumina slurries with the solid loading.

The microstructures of the green bodies fabricated using different solid loadings and air pressures are shown in Fig. 4. There were no microcracks or porosity in any of the green bodies. In the case of the slip-casting method, the green body generally contains porosity caused by the pores present in the slurry [2-6]. However, there was no porosity in our experiment.

Fig. 5 shows the microstructures of the bodies after sintering. All of the specimens had a dense structure and there were no inner porosity or cracks. The grains had a circular or rectangular structure due to the gypsum mold.

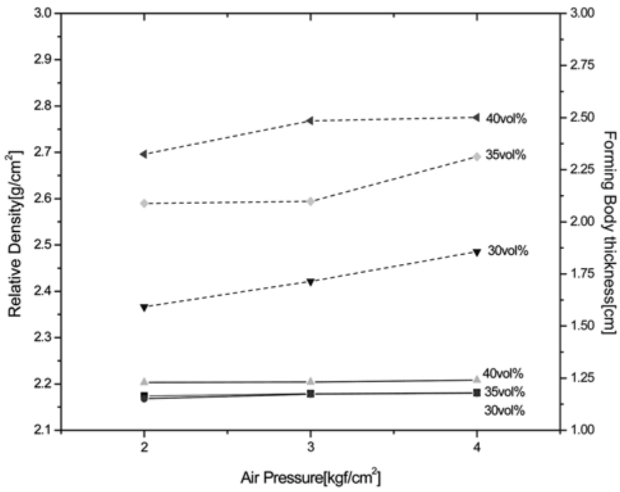


**Fig. 3.** Relative density and thickness of the forming body as a function of the air pressure and solid loading.

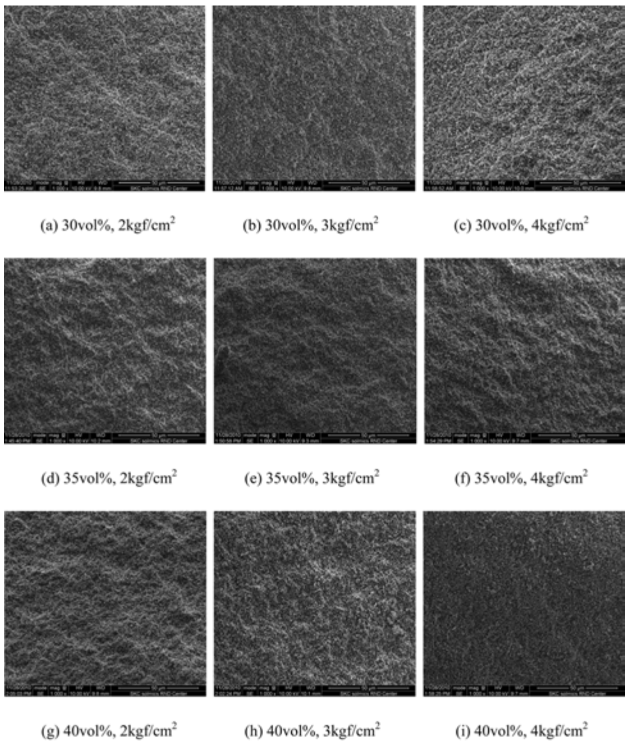


**Fig. 4.** Microstructures of the formed bodies

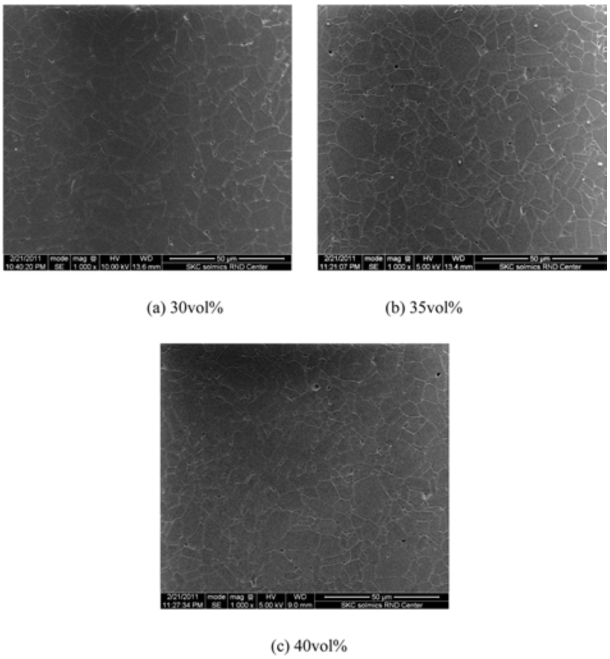


**Fig. 5.** Microstructures of the sintered bodies with different solid loadings (air pressure 2 kgf/cm$^2$).

## Conclusion

In this study, the properties of green and sintered alumina bodies fabricated by a modified slip casing method were investigated as a function of the solid (loading and air pressure). The bulk density increased with an increase in the solid loading, but varied very little with an increase in the air pressure. The volume of the green body and its compatibility increased with increasing air pressure. There were no microcracks or pores in the green bodies and the sintered bodies had a dense microstructure. Therefore, the manufacture of dense green bodies is possible by the proposed modified method. Also, the difficulty of manufacturing large area green bodies is expected to be solved by this modified method.

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