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Effect of CaO Addition on the Sintering Behaviour of Anorthite Formed from Kaolin and CaO

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Thermal reactions and sintering behavior of kaolin DD3 (Djebel Debbagh, Algeria) and CaO mixtures to obtain dense anorthite ceramics were investigated. Mixed powders were uniaxially pressed and fired between 850 and 1150 °C. Firing the pressed specimens yielded a dense anorthite ceramics. The sintered density increased with increase of CaO content and reached the maximum value of 2.57 g/cm^3 for the composition containing 10 wt% CaO and fired at 1150 °C. Their coefficient of linear expansion of the sintered samples at 1100 °C decreases with the addition of CaO. X-ray diffraction experiments carried out on the samples containing varied amount of CaO and fired at the temperatures higher than 1000 °C for 2 h showed the presence of only anorthite phase.

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1. Introduction

Many studies have been directed at developing alternative ceramics to replace conventional alumina substrate for an increase in semiconductor integrated circuit performance, such as high density. Ceramic substrates should have low sintering temperatures [1–6]. Anorthite is the best member in place of alumina substrate with a relatively low density of 2.76 g cm^{-3} [7]. Anorthite polycrystalline ceramics also satisfy the requirements of ceramic substrates due to its lower thermal expansion coefficient and lower dielectric constant than alumina. The sinterability of anorthite substrates at low temperature have never been fabricated due to the difficulty of sintering anorthite particles below 1000 °C. Harabi et al. [8] investigated the sintering phenomenon in kaolin–calcite mixtures for application as porous ceramic supports. However, they concluded that the sintering of these mixtures never proceeded below 1200 °C. Probably, the kaolin used in their studies was too coarse to get sinterable mixtures [9].

In this study, we are using kaolin DD3 from Djebel Debbagh (Algeria) and CaO mixture. A dense anorthite was obtained with low-temperature firing below 1000 °C. Also, we studied the effect of CaO additions, on the sintering of the prepared anorthite by several methods such as X-ray diffraction (XRD) and dilatometry.

2. Experimental procedure

Algerian raw kaolin DD3 (from Djebel Debbagh, Algeria) and calcium hydroxide ($Ca(OH)_2$) were used as starting materials. Before preparing the mixture, the crystalline kaolin was calcinated at 700 °C for 2 h to yield metakaolin in amorphous state. The chemical analysis of metakaolin by X-ray fluorescence spectroscopy is given in previous work [10]. The mean particle sizes of the mixture before and after ball-milling were 8.01 µm and 1.5 µm, respectively (Fig. 1). As it can be clearly seen, the powder presents a bimodal distribution with size between 0.25 and 44 µm and between 0.125 and 32 µm for the raw and the milled mixture powder, respectively (Fig. 1a,b). Metakaolin and calcium hydroxide were weighed according to the stoichiometric anorthite composition. These powders were wet mixed and milled in distilled water for 5 h using zirconia balls. All mixtures powder were dried at 110 °C for hours and then uniaxially pressed at 50 MPa to form a disk of 13 mm in diameter. Afterwards, the green compacts were sintered at temperature in the range 850–1150 °C with a heating and cooling rate of up 5 °C/min. The phases formed after sintering were identified by XRD using Cu K radiation.

Powders were characterized by differential thermal analysis (DTA/TG) using Setaram Labevo with heating at 20 °C/min. The phases formed after sintering were identified by powder X-ray diffractometry (Shimadzu model 5600 with Cu K_α radiation). The thermal expansion of sintered samples was determined using a dilatometer (Netzsch Dil 402C). Bulk density was determined by the Archimedes immersion.

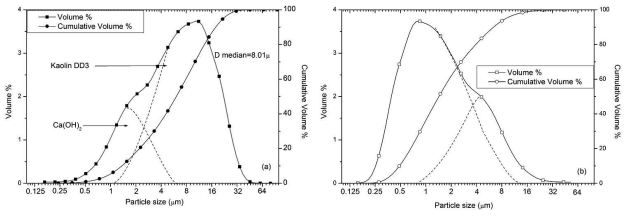

Fig. 1. Particle size distribution [vol.%] and [cumulative vol.%] of raw materials before (a) and after (b) ball-milling.

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