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Abstract

Aluminium Anodizing Slurries as an Additive for FLASH Sintering of Alumina †

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Ensuring sustainable development and drastically reducing the high energy consumption associated with industrial processes is no longer an objective, it is currently mandatory. In this sense, the European Union has adopted ambitious policies with the aim of Europe becoming the first continent with a neutral climate impact by 2050 (The European Green Deal). The ceramic industry is a highly energy-intensive sector, with manufacturing energy costs of up to ~60% of manufacturing cost/piece. Alumina is one of the most important technical ceramics due to its nearly omnipresent use and wide application range (electrical insulator, refractory, to advanced applications). However, temperatures of 1500–1700 °C are required for sintering. To make Al_2O_3 manufacturing more sustainable, energy reduction is mandatory. One possible alternative is FLASH sintering. FLASH consists of the direct application of an electric field to a material, resulting in an induced current where heat is generated by the Joule effect, which allows for very rapid densification. Although FLASH has been successfully reported for semiconductor materials, insulators, such as alumina, remain a challenge. This work aims to exploit FLASH of alumina with the addition of aluminium anodizing slurries. These slurries were calcined at 900 °C, sieved at 65 μm and mixed with alumina to provide higher electrical conductivity. The used slurries are mainly composed of Al_2O_3, SO_3 and Na_2O, 64.3 wt.%, 23.4 wt.% and 8.7 wt.%, respectively. Different proportions of slurries (0, 10, 20, 40 wt.%) were used to analyse its influence on the FLASH process and final properties of the FLASH sintered materials. Pure alumina was mixed with the slurries and ethanol in a planetary mill for 5 h at 200 rpm using Teflon jars. Dried powders were pressed and sintered, by conventional and FLASH processes, at a constant heating rate of 5 °C/min until the desired temperature, at 1550 °C for 2 h, for conventional sintering, and until FLASH occurs, 500–970 °C, for 60 s, for the alternative process. For FLASH sintering, an electric field of 800 V/cm was applied and a current limit of 2 mA/mm^2 was used. Our results show that the use of the aluminium anodizing slurries allows to FLASH alumina. The FLASH temperature decreases as the slurry content increases, reducing from 970 °C, with 10 wt.% of slurries, to 500 °C, with 40 wt.%. All specimens exhibit densification of at least 90%, which is promising for the attainment of a fully dense material by FLASH. In conclusion, FLASH sintering of alumina composites with aluminium anodizing slurries allowed to reduce the maximum sintering temperature up to 800 °C, and the time of sintering was also reduced from 2 h to 60 s. Therefore, aluminium anodizing slurries is a potentially viable and sustainable alternative solution for, on one hand, lowering the sintering temperature and time of alumina, namely by FLASH sintering and, on the other hand, reusing industrial waste, contributing definitely to a more sustainable process of alumina ceramics.

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