Development of High-Speed Cushioning Materials Using Alumina-Zirconia Ceramic Composites

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Abstract. Today modern ceramics are widespread and popular. To be used as a component in the production of medical parts and equipment. or in military work Because it has outstanding properties of hardness. Environmentally friendly and will not rust. But there are still strength properties that are still needed and are likely to increase in other engineering applications this research therefore aims to study and develop modern ceramics with high strength. But still maintains its hardness properties. By using metal powder, alumina powder particles with a fineness level of not less than 20 nanometers for mixing to produce Al_2O_3-ZrO_2 composite materials in ratios of 100/0, 96/4, 95/5, 94/6 wt% using sintering temperatures of 1,600 and 1,700 degrees Celsius, respectively.

Keywords: Composite ceramics, Zirconia, Sintered

Introduction

Ceramic materials that are popularly used to make bulletproof armor include alumina ceramics because alumina has high hardness and maintains its strength at high temperatures [1]. It is resistant to heat, chemicals and various environmental conditions compared to metals and plastics, and is also cheap compared to other types of ceramics. However, alumina itself has limitations in its use as bulletproof armor, especially in terms of toughness and easy cracking [2]. Therefore, there has been a lot of research that has tried to improve the mechanical properties of alumina by using various additives mixed with alumina to form composite materials. Chromium (Cr_2O_3) has been used to improve the mechanical properties of alumina, especially in terms of hardness and strength. Ceramic materials in the alumina-chromia (Al_2O_3-Cr_2O_3) system are materials that are used in engineering, such as as cutting tools [4]. and bulletproof armor. There is a lot of research that has been done to improve the mechanical properties of alumina by using chromium. However, from the study of ceramic materials in the alumina-chromia system (Al_2O_3-Cr_2O_3) It was found that adding chromium (Cr_2O_3) can make ceramic materials with better mechanical properties, especially toughness, but it will increase only slightly. There are still limitations in using it as a bulletproof armor, which requires materials with high toughness that can withstand the impact of bullets [5]. Therefore, this research is interested in using zirconia (ZrO_2) as a mechanical property enhancer for alumina-chromium ceramics by using the proportion of Al_2O_3 and ZrO_2 at 20 nanometer particles in the ratio of 100/0, 95/5, 96/4, 95/5and by weight [6]. respectively, by controlling the sintering temperature at a temperature of 1,600-1,700 degrees Celsius in order [7].to know the desired toughness properties because zirconia has more prominent toughness properties than other types of ceramics.

Material and Experimental Methods

1.1 Material

Table 1. Compositions of alumina-zirconia ceramic composites

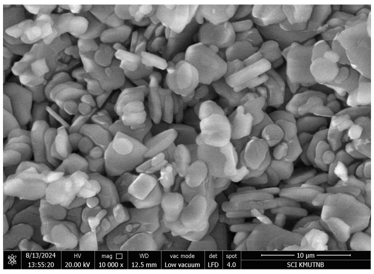
Materials composites	Specimen1 (wt%)	Specimen2 (wt%)	Specimen3 (wt%)	Specimen4 (wt%)
Alumina (Al_2O_3)	100	96	95	94
Zirconia ZrO_2	0	4	5	6

The alumina-zirconia ceramic composite specimens contained as shown in Table 1.

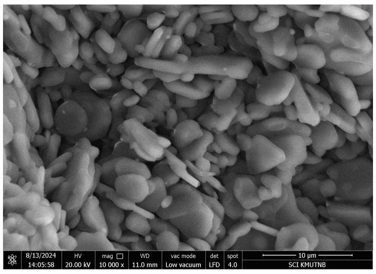
1.2 Experimental methods

The mixture is pressed and dried, then weighed before and after sintering. The sintering temperature is 1,600-1,700°C and the temperature is maintained for 30 minutes. The furnace used for sintering is a closed furnace with LPG as fuel. The sintered composite materials are examined for their morphological structure using a high-power microscope to find sintering defects. The samples used in the experiment are … and … with a resolution of 20nanometers. The mold used for sintering the test pieces is round, 50 mm in diameter and 8 mm thick, made of SKD61 material. The force used for powder forming is 50Psi.

1.3 Results and Discussions



Specimen1



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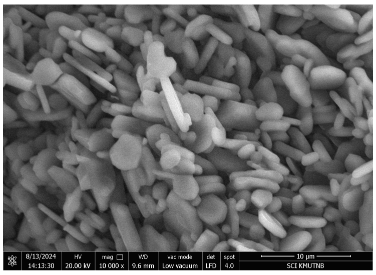
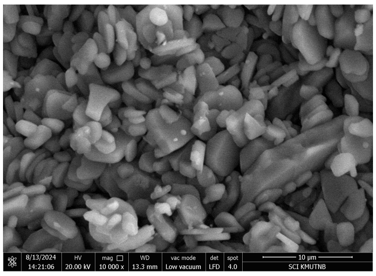


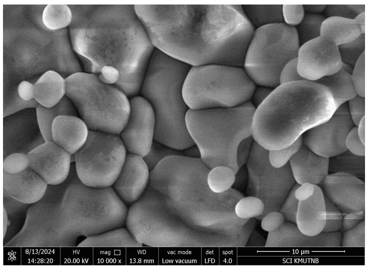
Specimen3



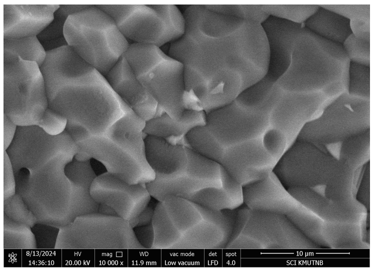
Specimen4

Fig. 1. sintering temperature at 1,600 ºC of compression temperature

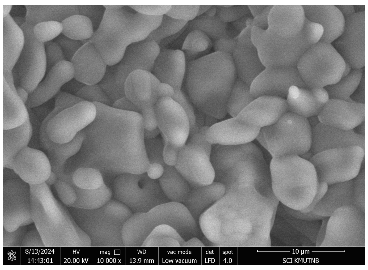
Fig. 1 shows the picture by Scanning Electron Microscope (SEM) 10,000x sintering temperature at 1,600 ºC of compression (specimen 5, 100:0 wt% of Al_2O_3 :ZrO_2) (specimen 6, 96:4 wt% of Al_2O_3 :ZrO_2) (specimen 7, 95:5 wt% of Al_2O_3 :ZrO_2) (specimen 8, 94:6 wt% of Al_2O_3 :ZrO_2) not less than 20 nanometers.



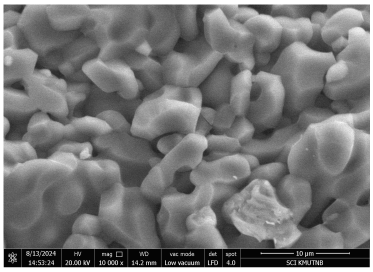
Specimen5



Specimen6



Specimen7



Specimen8

Fig. 2. sintering temperature at 1,700 ºC of compression temperature

Fig. 2 shows the picture by Scanning Electron Microscope (SEM) 10,000x sintering temperature at 1,700 ºC of compression (specimen 5, 100:0 wt% of Al_2O_3 :ZrO_2) (specimen 6, 96:4 wt% of Al_2O_3 :ZrO_2) (specimen 7, 95:5 wt% of Al_2O_3 :ZrO_2) (specimen 8, 94:6 wt% of Al_2O_3 :ZrO_2) not less than 20 nanometers.

Conclusions

In this study, the morphological physical characteristics of Al_2O_3 and ZrO_2 at the designed ratio were investigated, and by sintering at 1,600 and 1,700 degrees, it was found that the roundness and grain size had a direct effect on the strength and toughness of the ceramic composites, which from the figure shows that the characteristics of sample 8 (94:6 wt% of Al_2O_3 :ZrO_2) are consistent with the observations. However, it was also found that higher temperatures will result in more spherical structure of Al_2O_3 and ZrO_2 which is also beneficial.

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