Investigation In to Some Electrical Properties of Ytteria – Silicon Carbide ,Ceramic Composites

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Abstract: Ytteria ,silicon carbide powders of (99.99) purity having (40) µm grain size were used to form different combinations of the system Y2O3- SiC . Silicon carbide particles was added in weight percent ranging (5,10,15and 20), dry milling were done for all the combinations at 8 hours .Samples of disc shape were fabricated and sintered at different temperature (800,1000,1200, 1400 and 1500) °C ,under static air and for three hours as soaking time .Porosity for all sintered samples were measured . SEM after sintering were detected too .Electrical properties were studied to find the dielectric constant , breakdown voltage and the capacitance were don. Improvement in its electrical properties were achieved at all the combinations after adding the dispersed Sic particles . And especially at the combination (Y2O3 80-SiC20)Wt.% , that sintered at1500 °C.

Keywords: ceramic composites , Sintering , Dielectric constant , Brake down voltage , Capacitance

1.Introduction

The composite materials mainly consist of two or more than material can be intimately bonded to have a new material with unique properties compared with their consistent .As all composites ceramic materials ,ytteria –matrix composites can be tailored . By addition of high strength ,high temperature resistance ,high hardness to get attractive properties with the ability to operate under high temperature .Silicon carbide is a filler material can be used successfully due to its excellent properties ,such as high thermal conductivity ,low coefficient of thermal expansion ,high modules and low density [1] . Chemical properties reflect its high stability during synthesis under severe conditions .SiC particles can be used with other materials ,like metals Al-SiC metal matrix composites .Ytteria in recent twenty years received many scientific attention in many fields , because of its excellent properties such us high dielectric constant ,low absorption in broad range (near UV to IR),superior electrical brake down voltage and low leakage current [2] . Yttrium oxide is one of the most important compounds of yttrium and accounts forth largest use. It is widely used in making YVO4 europium, and Y2O3 europium phosphors to give the red color in color television tubes. Many hundreds of thousands of pounds are now used in this application. Yttrium oxide also is used to produce yttrium-iron-garnets, which are very effective microwave filters. It also has potential use in ceramic and glass formulas, as the oxide has a high melting point and imparts shock resistance and low expansion characteristics to glass. Hard, dense layers are deposited by electron-beam evaporation .In the current investigation our goal is to study the effect of adding silicon carbide on the microstructure and electrical properties of ytteria after sintering proses.
2. Experimental details

2.1 preparation of \( Y_2O_3 - SiC \) composites ceramic material.

High purity ytteria and silicon carbide of 40 µm, were used to fabricate the composites ceramics. Different weight percentage ranging (5,10,15,20) SiC were dry mixed with the matrix ytteria at soaking time 8 hrs. Discs of 2 cm in diameter were compacted to be ready for sintering process. Different sintering temperature used under static air, starting step by step to get the sintering behavior, gradually from (800,100,1200, 1400 and 1500) °C. The sintered body of three samples from each combination are ready to be test.

2.2 Characterization of samples

The fabricated samples(Disc shape), from each combination after sintering was measured its porosity, by using Archimedes’ method. Scanning electron microscopy were applied to study its microstructure after sintering. And by applied the required electrical conditions to calculate the dielectric constant, brake down voltage and capacitance. The tests were done according to the ASTM D374/374M [3], by using high accurate instruments having a well calibrated test (± 0.01) tolerance in measurements.

3. Results and discussions

3.1 Characterization

The composites ceramic after sintering proses its sintering activity reflect the behavior of its grain size and porosity distribution. This can be seen from the figure 1, which shows the relation between the sintering temperature and porosity for all the combinations. The silicon carbide act as sintering aid [4], by reducing the porosity with increasing its weight percentage added to the matrix, this behavior was noticed at all sintered temperature having maximum value of (68) and reached minimum value (50), for the silicon carbide 5 weight percent sintered at temperature 800 °C. While at the weight percentage 20 from silicon carbide the maximum value is (52) and reduced to be (12) as a lowest value reached after sintering temperature at 1500 °C.

![Figure 1](image-url). The Porosity behavior with respect of Wt.%SiC, at different sintering temperatures.

The well homogenization between the silicon carbide particles and yttrium oxide particles lead to get this improvement in porosity distribution compared with the matrix [5]. More
over the formation SiO₂, liquid phase [6] lead to increase the sintering density [7], and reduce the porosity. The results found in porosity distribution correlated to the changes in grain size after sintering [8], as shown in figure 2(A,B) the scanning electron micrographs of ceramic composites representative by the combination (Y₂O₃ 95 Wt.% - SiC 5 Wt.%) sintered at 1500 °C, showed the gain size distribution with open porosity figure 3 (A). And in figure 2 (B), the SEM micrographs of the combination (Y₂O₃ 80 Wt.% - SiC 20 Wt.%) sintered at 1500 °C, the grain growth exist with mass transportation forming the closed porosity [9].

![SEM micrographs](image)

**Figure 2.** SEM micrographs, a) Y₂O₃ 95 Wt.% - SiC 5 Wt.% , b) Y₂O₃ 80 Wt.% - SiC 20 Wt.% , Sintered at 1500 °C.

The dielectric constant as a function of silicon carbide added to the ytteria was tested for all combinations sintered at different sintering temperatures as shown in figure 3. The general behavior shows the decreasing in K value with respect to the silicon carbide added and increasing in sintering temperature. The highest value signed at sintering temperature 800 °C, for the 5 weight percent SiC added. And lowest one at sintering temperature 1500 °C, for the 20 weight percent SiC added. This behavior focus on the microstructure changes [10] and porosity distribution that drive the space charge in addition to the surface roughness [11]. The capacitance calculations reflect and matched the same results with K and for all combinations as shows in figure 4.

![Diagram](image)
Figure 3. The dielectric constant with respect to the SiC weight present, sintered at different temperatures.

Figure 4. The Capacitance of the composite ceramics with respect to the SiC weight present, sintered at different temperatures.

The breakdown strength analysis for all combinations after sintering shown in figure 5, the increasing in ability to stand the voltage applied was noted with the increasing in silicon carbide added and with increasing in sintering temperatures having minimum value of 1.5KV/mm for 5 weight percent SiC added, sintered at 800 °C, and maximum value of 6.5KV/mm for 20 weight percent SiC added, sintered at 1500 °C. Based on this data the thickness dependence explain the increasing in breakdown strength by impeded electrons or hole through the test samples that deeply effected by the surface roughness and porosity distribution [12].
Figure 5. The Break down strength of the composites ceramics with respect to the SiC added, sintered at different temperatures.

4. Conclusions

The effect of added dispersed silicon carbide particles of (40) µm was shown at all the fabricated compacted composites ceramics sintered at different sintering temperatures ranging from (800, 1000, 1200, 1400, 1500) °C, under static air for 3 hours. Clear improvement in sintering density was noticed by the microstructure and porosity distribution. Dielectric constant, capacitance and break down voltage were improved comparing with the matrix. The improvement signed at the combination (Y2O3 80 Wt.% - SiC 20Wt.%), sintered at 1500 °C, under static air for 3 hours.

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