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Improvement Microstructural and Damage Characterization of Ceramic Composites Y_2O_3 – V_2O_5 with MgO Nano Particles

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Abstract. Compacted samples of Y_2O_3-V_2O_5 – MgO Nano – particles wt. % sintered at different sintering temperature (700, 900, 1100, 1300)) C° for 2 hours under static air were investigated by x-ray diffraction and differential thermal analysis(DTA) ,to identify the phase present .Microstructure examination achieved by scanning electron microscopy .Sintered density and porosity were measured for all sintered samples .Compression was tested too and the Brake down voltage and dielectric strength were measure for all sintered samples .The clear improvement were noticed in both microstructure and damage characterization respectively after existing the MgO Nano-particles ,by increasing in about 30% in sintered density and 25% for the compressive strength .The improvement also noticed on both brake down voltage and dielectric strength.

Keywords: Nano MgO; Sintering; Improvement; Microstructure.
PACS: 61.46.+w, 42.50.Wk

INTRODUCTION

Y_2O_3 has been reported to have a good dielectric properties, thermal stability up to 2200 C°, and of dielectric constant 12 – 20 and low leakage current [1]. Low absorption in broad range (near – UV to IR), superior electrical brake – down (> 3MV/cm) remarkable luminescence render it widely be used in fluorescent lighting, color television, computer monitors, flat panel display, X-ray imaging and amplifiers for fiber –optics communication [2, 3], improved resistance to molten titanium and metals. As ceramic it is a super-excellent media for high brightness laser and Yttria – stabilized zirconia was used in alumina – zirconia abrasives, bearings and seals, high temperature refractories for continuous –casting nozzles jetengine coating, oxygen sensors in automobile engines, and wear-resistant and corrosion –resistant cuttintools [4]. Vanadium forms a number of different compounds with oxygen, depending on the oxidation state of the vanadium metal. The most common of these [5] is (vanadium pent oxide or vanadic anhydride), V_2O_5, it's the most stable oxide. Vanadium oxide is used extensively as a recent years, scientists have intensified their research in the field of nanoparticles mainly due to the innovative and catalyst in many industrial chemical reactions. It is also used in optical applications such as making of laser crystals and in Nano fiber and nanowire applications and in the manufacturing of some alloys and

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ceramics. In the unexpected results that are achieved through altering the atomic and molecular properties of various elements. Nano MgO is odorless and non-toxic white powder and has wide applications in producing electronics, catalyst, ceramics, oil, paint and other fields. With the growing demand of light weight, sound insulation and thermal insulation. Compared with traditional materials, magnesium oxide nanoparticle is non-toxic, tasteless and only need a small amount, so it is ideal for the development of new material with small additives. Electric insulating material for making crucible. High-frequency magnetic-rod antenna, magnetic device filler [6]. Sintering is a manufacturing process in which a fine powder that has been formed into a shape is subsequently fired at high temperature [7].

MATERIALS and METHOD

The Y_2O_3 and V2O5 powder , was analyzed for particle sizes ranging between (50 -70) microns were generally utilized as starting materials throughout the present investigation.V_2O_5 of fractions (3 wt. %). MgO of 90 Nano particle size were added as (0.5, 1, 1.5, 2 and 2.5) Wt.%. Dry mixed with Y_2O_3- V_2O_5 3wt.% were done by using mixing technique. Discs of 2 cm. diameter were compacted, three samples for each weight percentage were prepared. Sintering was performed at a various temperatures ranging from (700, 900, 1100, 1300) C° for 2 hours under static air. X-ray diffraction was carried out by SHEMADU XRD – 600 (Japan) , and differential thermal analysis ,DTA by using LINSEIS STA (Germany) ,for the combination Y_2O_3 - 3wt.% V_2O_5 – 2.5wt.% MgO after sintering at 1300 C°, was done at 5 C°/min. and from (25 – 1300) C°, in an ambit atmosphere. Densification measurements were based on volumes determined using micrometer measurements and accurate weight measured by an electronic balance. Microstructure examination was carried out for the sintered specimens using scanning electron microscope SEM –VEGA, TESCAN (Geake Republic). Compression strength tested to. The testing were carried out by using the mechanical universal testing machine (INSTRON ,Model Ms-1TA .Finally brake down voltage and dielectric strength were tested for the all combination sintered at 1300 C°, under static air.

RESULTS AND DISCUSSION

The X-ray diffraction for the sintered combination Y_2O_3- 3 wt.%V_2O_5 – Nano MgO sintered at 1300 C^o, its very clear form its profile that there is no any phase changes after adding V_2O_5 and MgO as sintering aid and the resulting spectrum is belongs to Yttria. [8]Thermal analysis (DTA), reflect a consistency results with X-ray diffraction, by no phase transformation (Exo.) [8], can be notes after the sintering and adding vanadium pent oxide and magnesia, while decomposition notes at 68 C^o, which is belong to the water molecules caused by the surrounding atmosphere as shown in Figure 1. In Figure 2, we can observe the sintering density of the Y_2O_3 -3 wt.% V2O5 –Nano MgO, sintered at various sintering temperature under static air for 2 hours. The compacts containing, (0.5, 1, 1.5) wt.% MgO showed an increasing in density with maximum value reached at (3.86gm/cm3) for the combination Y_2O_3 – V_2O_5 3 Wt.% -

1.5 Wt.% Nano MgO sintered at 1300 C°. Sintering process also effecting the porosity to be reduced from (7.20 – 6.13) for the Y_2O_3-3 wt.% V2O5 and Y_2O_3 – 3 Wt.% - 1.5 Wt.% Nano MgO respectively sintered at 1300 C°, as shown in figure3. While the densification shows a drop after adding 2.5 Wt.% Nano-MgO be (2.48 gm./cm^3) and increasing in the porosity to be (7.51) Figure2, and Figure3, respectively. This results giving the consistency with the sintering behavior [8]. The micro structure investigation of the ceramic compacts showed results consistent with the sintered densities. Some representative SEM micrographs for samples sintered at 1300 C°, for 2 hours in air are shown in Figure4. The combination Y_2O_5 -3Wt.% V_2O_5 showed evidence of the ultra fine particles, 10 micron of grain size, Figure 4a. Whereas after adding the Nano –MgO of 1.5 Wt.% the final sintering stage of 5 micron particle size, begins when adjacent necks begin to impinge upon each other, densification and grain growth occur during this stage with close–pore structure [9, 10] , Figure 4b. Figure 4c shows the reduced grain size of 20 micron after adding (2.5Wt.% Nano-MgO) ,the clear difference were found in size and location of porosity it seems that the MgO particles tend to shrink away during the sintering process [11]. While the improvement in sintering activity of Y_2O_3 powder through the bulk transport mechanism result in net particle movement leading to the densification [11, 12]. Which shows the same behavior with those obtained from the compression test and both brake down voltage and the dielectric strength [13, 14]. The significant increase (Improvement) in its damage characterization (compression strength) especially at the combination Y_2O_3 – 3Wt.% V_2O_5 - 1.5 Wt.% Nano – MgO as shown in Table 1. And the same effect can be identify for the brake down voltage and dialectical strength having a maxim value of 31.70 (Kv) , and 7.07(Kv/mm), respectively, as shown in Table 2.

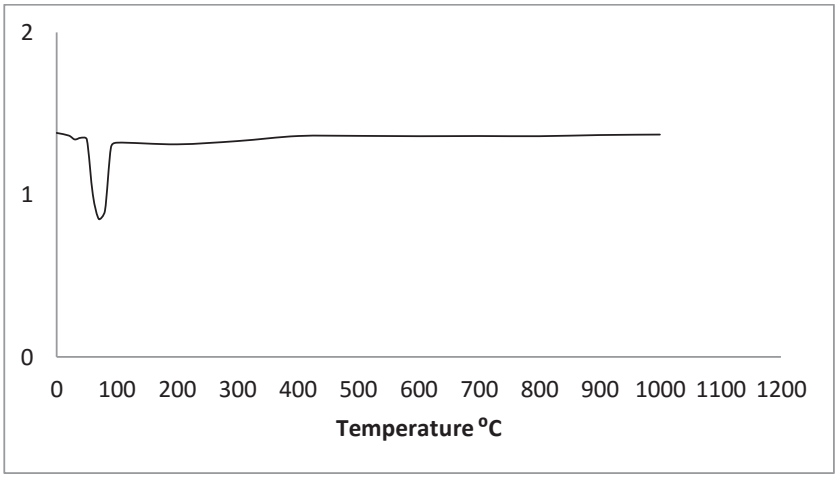

Figure 1. The DTA curve, scanning temperature vis 1) Endothermic 2) Exothermic of Y_2O_3 – 3wt.% V_2O_5- 2.5 Wt.% Nano MgO ceramic composite, sintered at 1300 C° for 2hours under static air.

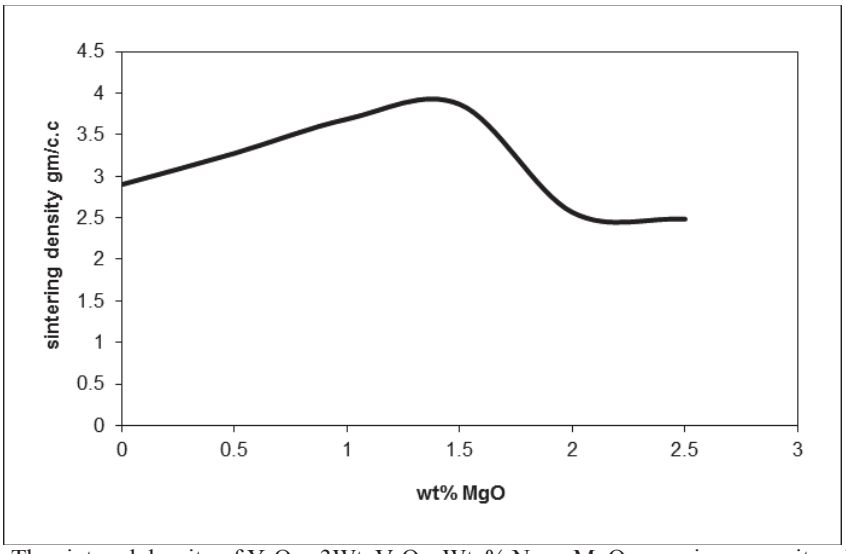

Figure.2. The sintered density of Y_2O_3 –3Wt. V_2O_5- Wt. % Nano MgO ceramic composite, sintered at different sintering temperature for 2 hours under static air.

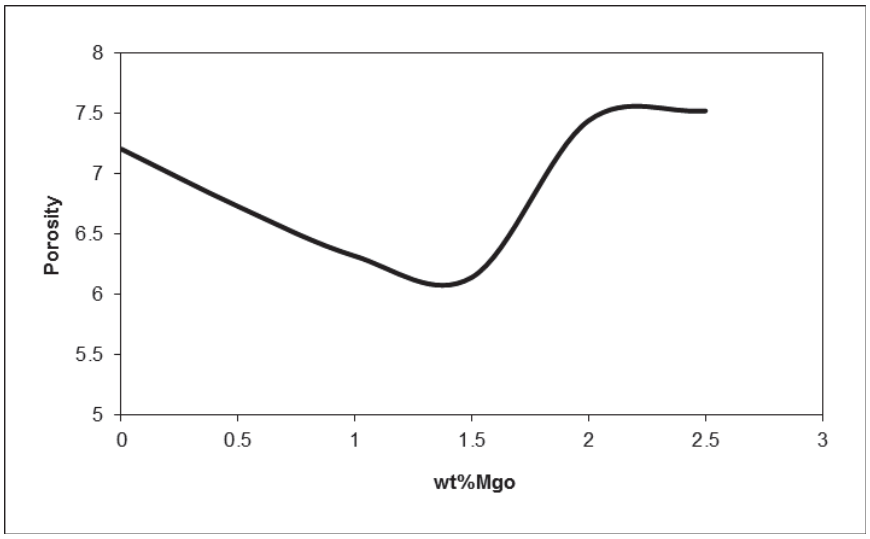

Figure 3. The porosity of Y_2O_3 –3Wt.%V2O5- Wt.% nano MgO ceramic composite, sintered at different sintering temperature for 2 hours under static air.

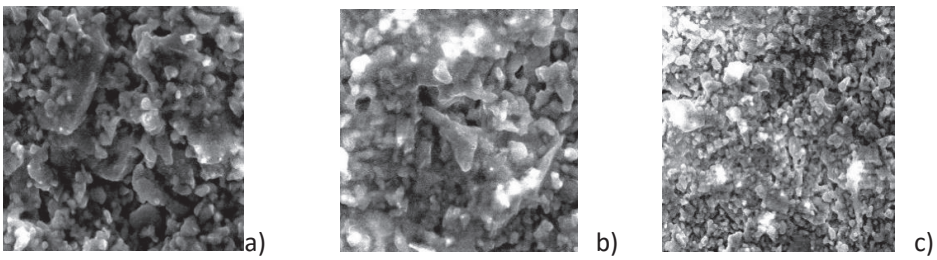

Figure 4. SEM micrographs for a) Y_2O_3 –3 Wt%. V_2O_5 of 10 μm grain size, b) Y_2O_3 -3 Wt.% V_2O_5-1.5Wt.% nano MgO of 5μm grain size, Y_2O_3 - 3 Wt.% V_2O_5 – 2.5Wt.% nano MgO, of 20 μm grain size. Sintered at 1300 C° for 2 hours under static air (Magnification 250X)

Table 1. The compression Strength for the ceramic composite Y_2O_3- 3Wt.% V_2O_5 – Wt.% Nano –MgO sintered at 1300 C°, for 2 hours under static air.

Ceramic Composite	Compression (MPa)
Y2O3- 3 Wt.% V2O5	12. 31
Y2O3-3Wt.% V2O5 - 0.5 Wt.% Nano MgO	5.23
Y2O3-3Wt.% V2O5 - 1 Wt %.Nano MgO	4.31
Y2O3 -3Wt. V2O5- 1.5 Wt.% Nano MgO	12.94
Y2O3 -3Wt.% V2O5 - 2 Wt.% Nano MgO	8.30
Y2O3 - 3Wt.%V2O5 - 2.5 Wt. Nano MgO	3.59

Table 2. The Brake down voltage and the dielectric strength for the ceramic composite Y_2O_3-3 Wt.% V_2O_5- Wt.% Nano- MgO sintered at 1300 C°, for 3 hours under static air.

Ceramic Composite	Brake down Voltage (kv)	Dielectric strength (kv/mm)
Y2O3 – 3Wt.% V2O5	4.59	16.50
Y2O3 -3Wt.% V2O5 - 0.5Wt.% Nano MgO	5.07	16.47
Y2O3 -3Wt.% V2O5 - 1Wt.% Nano MgO	27.70	5..10
Y2O3 -3Wt.% V2O5- 1.5Wt.% Nano MgO	7.07	30.70
Y2O3 -3Wt.% V2O5 - 2Wt.% Nano MgO	3.75	16.00
Y2O3 -3Wt.% V2O5- 2.5Wt.% Nano MgO	11.00	3.60

CONCLUSION

The densification of the Y_2O_3–3Wt.%V_2O_5 ceramics composites were increased at all sintering temperatures and indicate a higher sintering density at 1300 C^0 after adding nano MgO at (0.5,1,1.5)Wt.% respectively. The final sintering stage with a grain growth of 5 microns and close pore for the combination Y_2O_3–3Wt.%V_2O_5-1.5Wt.% Nano MgO was conducted. The damage characterization (compression strength), brake down voltage and dielectric constant were improved due to the improvement in sintering density.

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