Electrical Properties of Sintered Magnesium- titanate Ceramics

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Abstract

Mixtures of MgO and TiO_2 were mechanically activated in a planetary ball mill for different time intervals. Thus obtained powders were sintered in a furnace for 2 h at temperature of 1300 °C in air atmosphere. Raman scattering spectroscopy at room temperature has been used for characterization of sintered samples. Very similar spectra for all samples were observed, which indicate that there has been structure recovery during treatment at higher temperature. SEM analyses were performed in order to investigate effect of activation and sintering process on microstructure. Electrical measurements showed difference in dielectric constant (ε_r), loss tangent (tgδ) and specific resistance (ρ) as a function of time of mechanical treatment. The aim of this paper was to determine optimal parameters for materials preparation with a goal to obtain dense ceramic with appropriate characteristic.

The increase in activation time is beneficial to the densification after sintering and crystallizability until the loss tangent value reaches the minimum. The further increase in activation time is result in the appearance of abnormal grains and pores after sintering process and consequently leads to the increase of the tgδ value Specific resistance increase with milling time until 80 minutes is probably induced with existence large crack between areas. Sample MT-120-1300 has more compact structure and consequently lower values of specific resistance. The resultes pointed out that the dielectric permittivity of these specimens increase with activation time

Tab. I Electrical properties of sintered samples at 1 MHz frequency

Sample	ε_r	tgδ ·10^-3	ρ ·10^6(Ωcm)	d (% d_t)
MT-0-1300	29.3	9.37	3.43	84.17
MT-5-1300	31.2	8.54	3.90	87.76
MT-10-1300	30.7	8.40	3.99	88.45
MT-20-1300	29.0	8.43	4.24	88.35
MT-40-1300	30.0	8.24	4.28	89.79
MT-80-1300	31.6	8.04	4.37	92.02
MT-120-1300	33.4	8.29	3.73	90.99

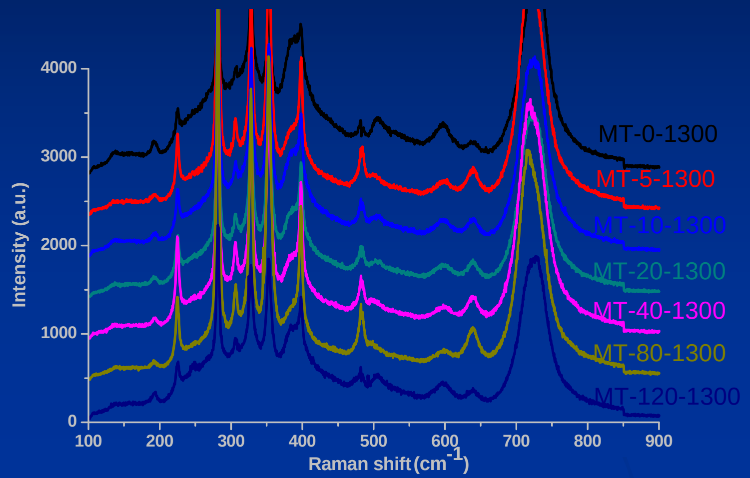

Fig. 1. Raman spectra of samples sintered at 1300 °C

During treatment at a higher temperature, two phased sistem ($MgTiO_3$ and Mg_2TiO_4) is formed. All ten bends corresponding to $MgTiO_3$ were observed, 225 cm^{-1} (A_g), 282 cm^{-1} (E_g), 307 cm^{-1} (A_g), 353 cm^{-1} (E_g), 398 cm^{-1} (A_g), 485 cm^{-1} (E_g), 504 cm^{-1} (A_g), 638 cm^{-1} (E_g), 728 cm^{-1} (A_g). On the other hand, only two modes of Mg_2TiO_4 are present, at ~328 and 481 cm^{-1}, only that there is overlapping mode at 328 cm^{-1} of Mg_2TiO_4 and 328 cm^{-1} (E_g) $MgTiO_3$. Also, one new bend is noticed at 596 cm^{-1} which is assigned to $MgTiO_3$ II. These high- pressure $MgTiO_3$ phase with the lithium niobate structure may be metastabile quench phase from perovskite.

Only difference is observed in intensity of some bends. From this point of view, as prolonged of mechanical treatment, peaks of perovskite decrease until 80 minutes, while peaks of spinel increase. Sample MT-120-1300 has very similar structures as MT-0-1300, which points us that, prolonged mechanical treatment facilitates decomposition of Mg_2TiO_4

Micrographs of samples sintered at 1300 °C for 2h indicate medium sintering stage along with enclosed but not spherical pores and two different phases. Presence of fracture between grains, which is due to presence of agglomerates in starting powders, was noticed. Observing morphology of MT-120-1300, may be noted that it is the most homogeneous structure, which cause the higher values of dielectric constant.

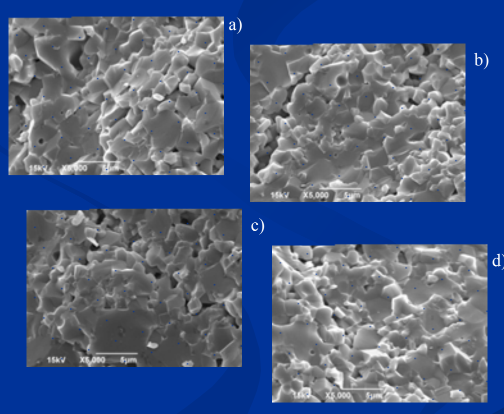

Fig. 2. SEM micrographs of samples MT-0-1300 (a), MT-20-1300 (b), MT-80-1300 (c) and MT-120-1300 (d).

Conclusion

Raman spectroscopy like as scanning electron microscopy of sintered samples indicates a presence of two phases ($MgTiO_3$ and Mg_2TiO_4). Varieties in spectra were explained with different ratio of present's phases. Mechanical treatment is responsible for greater values of densities after sintering. Values of dielectric permittivity increase with milling time, reaching maximum for the longest activated samples, ε_r=33.4 which makes it a good candidate for application in electronic industry, until loss tangent shows minimum values for samples MT-80-1300. Having all this in mind we can conclude that different preparation conditions result in different properties. This allows us to get adequate properties of material by adjusting conditions of preparation process, depending on the potential wide use of this ceramics.