

Structural and Spectroscopic Properties of MgTi₂O₅ / MgTiO₃ Composite by Solid State Technique

E. Izci

Physics Department / Anadolu University, Eskisehir, Turkey.

Composite materials have been in use in many different applications for a very long time. For many of their applications, ceramic powders are synthesized by conventional solid-state reaction method. The solid-state method of preparation requires repeated grinding and calcinations at high temperatures. This research is focused on the MgTiO₃/MgTi₂O₅ composite (MTO sample). At 600 °C, MgTiO₃ phase begins to form and it was clearly observed at 700- 900 °C. At 800- 900 °C, unreacted TiO₂ anatase partially converts to TiO₂ rutile phase and almost single phase MgTi₂O₅ at 1100- 1200 °C, is obtained [1].

The MTO sample was prepared by the conventional solid-state reaction method using stoichiometric amounts of high-purity MgO and TiO₂. The mixed powder was calcined and then it was milled. The milled powder was sintered in air at 1100 °C for 12 h. For the XRD analyses, the sintered powder was powdered in an agate mortar. It was mounted on a flat holder and examined by the powder method using a Rigaku DMAX diffractometer equipped with CuK α radiation in the region between 15° and 70°. The Bruker IFS 66 v/S FTIR system was employed for recording the spectrum using the KBr pellet method. The Raman spectrum was obtained with a Bruker Senterra Raman Spectrograph. The spectral resolution was 2 cm⁻¹ and spectral range between 70 and 4000 cm⁻¹. All of the investigations were carried out at a room temperature.

At the Figure 1, the XRD pattern of MTO sample used in this study shows characteristic features for MgTi₂O₅, rutile (TiO₂), periclase (MgO), and MgTiO₃. In the MTO sample, MgTi₂O₅ (ICDD file 35-792) and rutile (ICDD file 34-0180) are dominant with peaks found at 2 θ around 25.48°, 31.23°, 32.48°, 35.74°, 36.54°, 37.22°, 40.58°, 46.13°, 48.66°, 52.32°, 55.04°, 56.26°, 59.78°, 60.32°, 65.58° and with peaks around 2 θ of 27.42°, 36.06°, 39.16°, 41.22°, 54.32°, 56.66°, 62.72°, 64.06, 69.02°; and 69.78°, respectively. The presence of MgTiO₃ (ICDD file 06-0494 with peaks around 2 θ of 19.15°; 21.27°; 24.00°; 32.88°; 35.48°; 49.18°, 53.60°, 62.06°, and 63.72°) and periclase (ICDD file 43-1022 of 42.90°) is evident.

The FT-IR spectra of the prepared MTO sample, Figure 2, is in accordance with the XRD results. The band observed at 406.84 cm⁻¹ is assigned to the symmetrical stretching of Mg- Ti bending [2]. In addition, the band at 642.33 cm⁻¹ can be attributed to the symmetric stretching vibration of Mg- Ti. The bands at 1165.43 and 1139.85 cm⁻¹ bands at 1000 cm⁻¹ corresponds to the stretching and bending vibrations of Ti-O-Ti bonds. The characteristic bands in the range 400-700 cm⁻¹ are due to the different types of Ti-O- (Ti) vibrations, and they are related with tetrahedrally and octahedrally coordinated titanium ion [3]. To give an example, the band due to stretching mode of Ti- O bond is appeared at 461.92 cm⁻¹ [4]. The peak at 823.65 is assigned to the Ti-O stretching modes. There is also existence of a Ti₂O₃ peak at 473.49 cm⁻¹. The absorbance peaks at 489.88 and 608.78 cm⁻¹ become pronounced, confirming the existence of the rutile crystalline structure [5].

The Raman spectrum of the MTO sample is shown in Figure 3. The peak located at 619 cm⁻¹ corresponds to rutile [6]. The Raman bands at 169, 260, 359, 455, and 911 cm⁻¹ are due to the phase MgTi₂O₅ [7, 8]. The bands below 200 cm⁻¹ may be due to the lattice vibrations [8]. The band at 455 cm⁻¹ is assigned to the torsion of the O- Ti- O bond. The weak Raman bands at 257 and 207 cm⁻¹ are due to the additional phase MgTi₂O₅ [9].

References:

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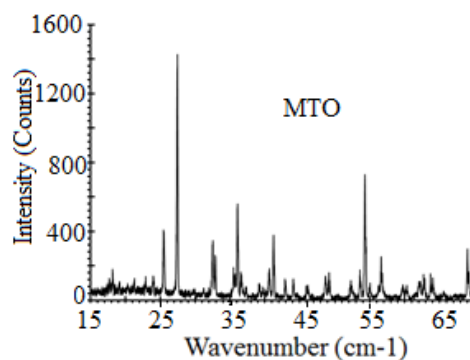


Figure 1. XRD patterns for the MTO sample sintered at 1100 °C.

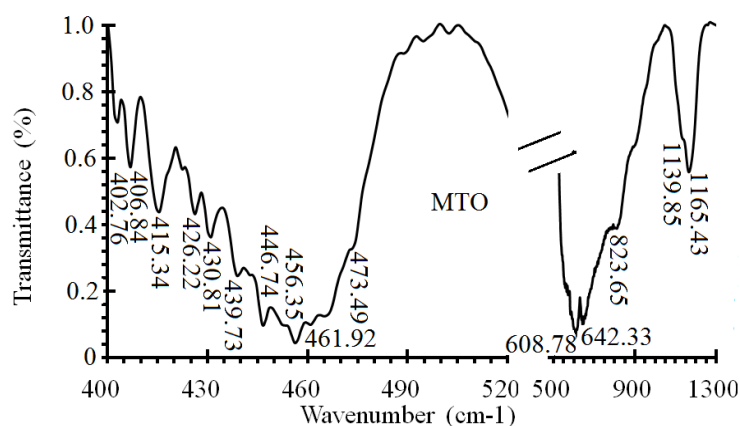


Figure 2. FTIR spectrum of the MTO sample sintered at 1100 °C.

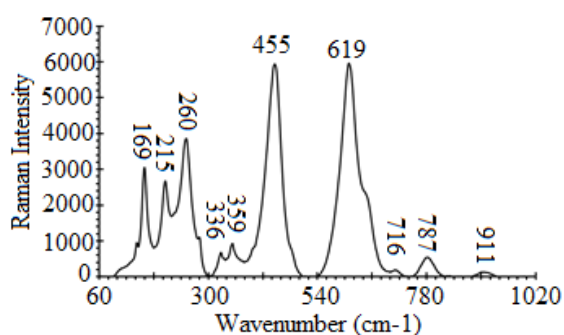


Figure 3. Raman spectrum of the MTO sample sintered at 1100 °C.