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Raman Spectroscopy Analysis of $MnTiO_3$-TiO_2 Eutectic

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Abstract : Oxide-oxide eutectic is attracting increasing interest of scientific community because of their unique properties and numerous potential applications. Some of the most interesting examples of applications are metamaterials, glucose sensors, photoactive materials, thermoelectric materials, and photocatalysts. Their unique properties result from the fact that composite materials consist of two or more phases. As a result, these materials have additive and product properties. Additive properties originate from particular phases while product properties originate from the interaction between phases. MnTiO3-TiO2 eutectic is one of such materials. TiO2 is a well-known semiconductor, and it is used as a photocatalyst. Moreover, it may be used to produce solar cells, in a gas sensing devices and in electrochemistry. MnTiO3 is a semiconductor and antiferromagnetic. Therefore it has potential application in integrated circuits devices, and as a gas and humidity sensor, in non-linear optics and as a visible-light activated photocatalyst. The above facts indicate that eutectic MnTiO3-TiO2 constitutes an extremely promising material that should be studied. Despite that Raman spectroscopy is a powerful method to characterize materials, to our knowledge Raman studies of eutectics are very limited, and there are no studies of the MnTiO3-TiO2 eutectic. While to our knowledge the papers regarding this material are scarce. The MnTiO3-TiO2 eutectic, as well as TiO2 and MnTiO3 single crystals, were grown by the micro-pulling-down method at the Institute of Electronic Materials Technology in Warsaw, Poland. A nitrogen atmosphere was maintained during whole crystal growth process. The as-grown samples of MnTiO3-TiO2 eutectic, as well as TiO2 and MnTiO3 single crystals, are black and opaque. Samples were cut perpendicular to the growth direction. Cross sections were examined with scanning electron microscopy (SEM) and with Raman spectroscopy. The present studies showed that maintaining nitrogen atmosphere during crystal growth process may result in obtaining black TiO2 crystals. SEM and Raman experiments showed that studied eutectic consists of three distinct regions. Furthermore, two of these regions correspond with MnTiO3, while the third region corresponds with the TiO2-xNx phase. Raman studies pointed out that TiO2-xNx phase crystallizes in rutile structure. The studies show that Raman experiments may be successfully used to characterize eutectic materials. The MnTiO3-TiO2 eutectic was grown by the micro-pulling-down method. SEM and micro-Raman experiments were used to establish phase composition of studied eutectic. The studies revealed that the TiO2 phase had been doped with nitrogen. Therefore the TiO2 phase is, in fact, a solid solution with TiO2-xNx composition. The remaining two phases exhibit Raman lines of both rutile TiO2 and MnTiO3. This points out to some kind of coexistence of these phases in studied eutectic.

Keywords : compound materials, eutectic growth and characterization, Raman spectroscopy, rutile TiO_2
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