Laser induced phase conversion from TiO_2 rutile to anatase.

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Titanium dioxide (TiO_2) is a wide band gap metal oxide semiconductor with numerous applications in science and technology [1]. The main fields are photovoltaics and photocatalytic water purification. Most studied TiO_2 polymorph phases are anatase, rutile and brookite. It is known that the anatase is more favorable for photocatalytic applications, while the rutile exhibits better optical and electrical performance [2]. In this study, the effects of laser radiation on TiO_2 rutile single crystals were investigated.

TiO_2 rutile single crystal (100) with 0.05% Nb doping was used in the experiments. In this study we have used 266 nm pulsed nanosecond Nd:YAG laser with pulse duration 5 ns and 10 Hz repetition rate. Raman spectroscopy was used to determine a polymorph phase change.

According to the Raman spectroscopy results, pristine TiO_2 single crystal consists of rutile. Irradiation by the pulsed laser leads to the partial phase change from rutile to anatase. Figure 1 shows Raman spectra of TiO_2 single crystal after the laser treatment. Observed Raman shift at 145 cm^{-1} (B1g), 241 cm^{-1} (multi phonon), 443 cm^{-1} (Eg), 612 cm^{-1} (A1g), corresponds to the rutile phase. After laser treatment, new anatase related Raman lines appeared at 203 cm^{-1} (Eg), 397 cm^{-1} (B1g) 516 cm^{-1} (A1g and B1g) and 637 cm^{-1}. Also, significant increase of 145 cm^{-1} (Eg) line indicates formation of anatase phase [3].

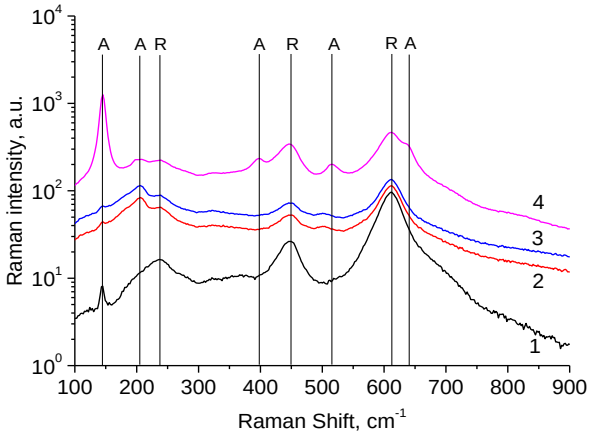

Fig. 1. Raman spectra of TiO_2 sample after irradiation by the laser with: 1 – 0 laser pulses, 2 – 100 laser pulses, 3 – 1000 laser pulses, 4 – 10000 laser pulses,

We have found that irradiation of TiO_2 single crystal by highly absorbed nanosecond 266 nm laser radiation leads to the partial conversion of rutile to anatase. The conversion can be explained by the thermal shock produced by the laser light.

We suggest that this method can be used for fabrication of a anatase single crystal layer on rutile crystal substrate.

References

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