Laser modification of TiO_2 thin films for applications in photovoltaics.

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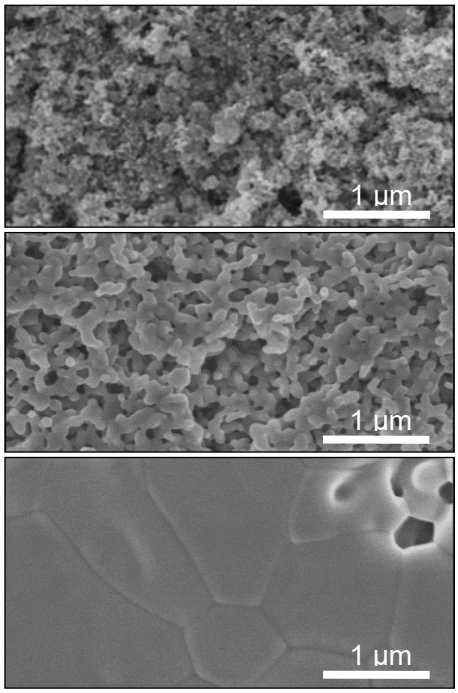
Titanium dioxide (TiO_2) is a wide band gap metal oxide semiconductor with numerous applications in science and technology [1]. The main fields are photovoltaics and photocatalytic water purification. Most studied TiO_2 polymorph phases are anatase, rutile and brookite. It is known that the anatase is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

TiO_2 thin films were prepared by spray pyrolysis technique on glass substrates from TiO_2 nanoparticles. After the heat treatment in furnace at 500°C for 3 h samples were modified by a direct laser write technique. In this study we have used the continuous wave (CW) 405 nm semiconductor laser and the 1064 nm pulsed nanosecond Nd:YAG laser. Raman spectroscopy was used to determine a polymorph phase change. Scanning electron microscopy (SEM) was used to characterize the morphology.

According to the Raman spectroscopy, pristine TiO_2 thin film consists of anatase. Irradiation by the pulsed laser does not lead to the phase change. However, irradiation by the CW laser leads to the conversion of anatase to rutile. Figure 1 shows SEM images of TiO_2 thin film after the laser treatment. Nanosecond laser irradiation leads to the sintering of TiO_2 nanoparticles without a change of the polymorph phase, but the CW laser leads to complete melting of the film and anatase phase is changed to rutile.



a) b) c)

Fig. 1. SEM images of as prepared TiO_2 film a), irradiated by pulsed laser b) and irradiated by CW laser.

Melted rutile film could be used as a compact under layer in the dye sensitized solar cells to improve efficiency. Moreover, in conjunction with anatase top layer the anatase/rutile heterostructure will be formed. This will also contribute to the photovoltaic efficiency.

References

[1] M. Grätzel, Nature 414, 338 (2001).

[2] H. Cheng and A. Selloni, Phys. Rev. B 79, 092101 (2009).