# Control of $TiO_2$ thin film density and mechanical properties by laser radiation.

**Shizuoka Univ. [1], Riga Technical Univ. [2], ◦Edvins Dauksta[1,2], Arturs Medvids[2], Vygantas Mizeikis[1] and Kenji Murakami[1]**

**E-mail: murakami.kenji@shizuoka.ac.jp**

Titanium dioxide ($TiO_2$) is a wide band gap metal oxide semiconductor with numerous applications in technology [1]. The main fields are photovoltaics and photocatalytic water purification. Commonly used $TiO_2$ polymorph phases are anatase, rutile, and brookite [2]. Recently, researchers started to focus on the development of flexible dye-sensitized and perovskite solar cells. In this study, the effects of laser radiation were investigated on the $TiO_2$ film density and mechanical properties.

$TiO_2$ thin films were prepared by the spray pyrolysis technique on glass substrates and ITO/PEN substrates. The spray solution was prepared from 0.3 g of $TiO_2$ Degussa P-25 powder, 20 ml ethyl alcohol ($C_2H_5OH$) and 5 drops of Triton-X. Samples were modified by a direct laser write technique without prior annealing in the furnace. In this study we have used 1064 nm pulsed nanosecond Nd:YAG laser with pulse duration of 6 ns and continuous wave UV 405 nm laser diode. Adhesion to the glass substrate was tested by sonication with 120 W power at 38 kHz in water for 1, 3 and 5 min. Samples on the flexible substrate where tested by bending. Raman spectroscopy was used to determine a polymorph phase change. Scanning electron microscopy (SEM) was used to characterize the morphology.

Raman spectroscopy results showed that the pristine $TiO_2$ thin film consists of anatase and the crystalline phase does not change after irradiation by the laser. Figure 1 shows the SEM microscopy image of the $TiO_2$ thin film after the laser treatment. Laser irradiation leads to the densification of $TiO_2$ nanoparticles without a change of the polymorph phase according to the Raman spectroscopy results. Moreover, the densified $TiO_2$ thin film has higher mechanical hardness and higher adhesion to the substrate than the pristine $TiO_2$ thin film.

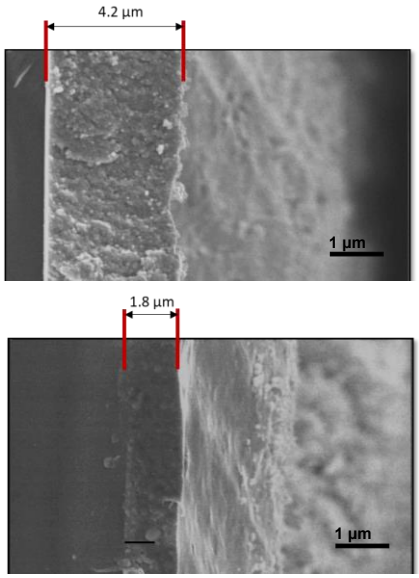


Fig. 1. SEM image of the $TiO_2$ thin film a cross section of after irradiation by the laser.

The improved adhesion of the $TiO_2$ can be used in the development of flexible solar cells.

**References**

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

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