「様式３」

Project No.： 2061

Phase Transformation from Rutile to Anatase with Oxygen Ion Dose in TiO_2 Layer Formed on Ti Substrate

(Divide a page into 2 columns)

［１］Organization: Riga Technical University
Project Leader： Prof. Arturs Medvids
Representative at RIE：Prof. Hidenori Mimura
Participants：

［２］**Research Progress** (10.5 points)

In this work oxygen plasma immersion ion implantation method was used for TiO_2 layers formation on Ti substrate by using different O^+ ion doses. The analysis of TiO_2 layers showed that the higher ion dose leads to phase transformations with the increase amount of anatase and reduction of rutile TiO_2 phase. This could be explained by metastable anatase TiO_2 phase formation due to shorter relaxation time of TiO_2 particles during the O-PIII with higher O^+ ion doses. These phase transformations cause an increase of the free surface energy from 39.0 mJ/m^2 to 49.5 mJ/m^2 as well as photocatalytic decomposition ratio from 3.2×10^{-3}min^{-1} to 4.2×10^{-3} min^{-1} under UV-A irradiation. An evidence of our suggestion is decrease of the implanted layer density from Ti (ρ=4.506 g/cm^3) through TiO_2 rutile (4.23 g/cm^3) to TiO_2 anatase (3.78g/cm^3) phase with the increase of O^+ ions implantation dose into the Ti substrate.

［３］**Results** (10.5 points)

（３－１）Research results

Oxygen plasma immersion ion implantation (O-PIII) method was used for formation of TiO_2 layer on Ti substrate. It was found that the content of anatase polycrystalline phase increased from 5.1 % to 22.3 % of total TiO_2 amount with higher O+ ion dose. The oxygen ion doses were 3.6×1016 ions, 8.1×10^{16} ions, 1.26×10^{17} ions, for 1, 2 and 3 hours respectively, with ion energies E≈0.8 keV. The polycrystalline phases and morphology of the obtained films were characterized by XRD, FESEM, AFM and Raman spectroscopy. Photocatalytic decomposition reaction constants of methylene blue solution increased from 3.2×10^{-3} min^{-1} to 4.2×10^{-3} min^{-1} under UV-A irradiation and liquid free surface energy increased from 39.0 mJ/m^2 to 49.5 mJ/m^2 with increasing of O-PIII treatment dose. These results are explained by the partial phase transition from rutile to anatase of TiO_2 layer. So, the increase of O^+ ions implantation dose into the Ti substrate leads to decrease the material density from Ti (ρ=4.506 g/cm^3) through TiO_2 rutile (4.23 g/cm^3) to TiO_2 anatase (3.78g/cm^3) phase.

（３－２）**Ripple effects and further developments**

In future we are planning to elaborate technology plasma immersion ion implantation (PIII) method when together with O^+ ions will be implanted metallic ions for absorption of solar radiation by TiO_2.

［４］Achievements (**List of Publications**) (10.5 points)

（１）**A. Medvids**, S. Varnagiris, E. Letko, D. Milcius, L. Grase, S. Gaidukovs, A. Mychko, A. Pludons, P. Onufrijevs, H. **Mimura**." Phase transformation from rutile to anatase with oxygen ion dose in the TiO_2 layer formed on a Ti substrate", **Materials Science in Semiconductor Processing**, Vol. 106, pp.104776, 2020.

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I was stay in Hamamatsu, Research Institute of Electronics of Shizuoka University, from 25 of September till 21 of November 2019.

Travelling Report

Name： Arturs Medvids
Affiliation：Riga Technical University
Period of time：from 25.09 till 21.11, 2019
Destination：Hamamatsu, RIE of Shizuoka University
Purpose：Joint project
Name of receiver：Prof. Hidenori Mimura