Nano-structureed TiO_2 Films by Plasma Electrolytic Oxidation of Titanium Combined with Chemical and Thermal Post-Treatments, for Dye-sensitited Solar Cell Applications

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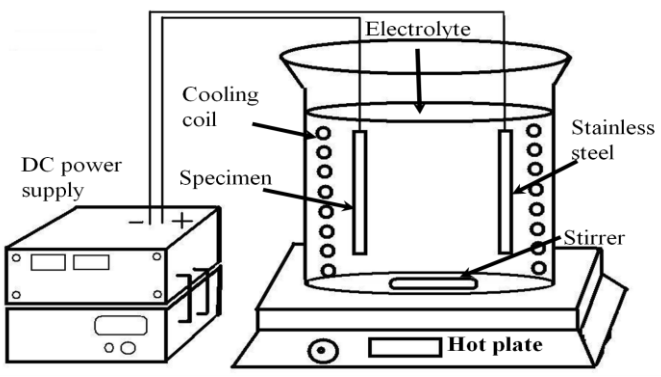
Introduction:

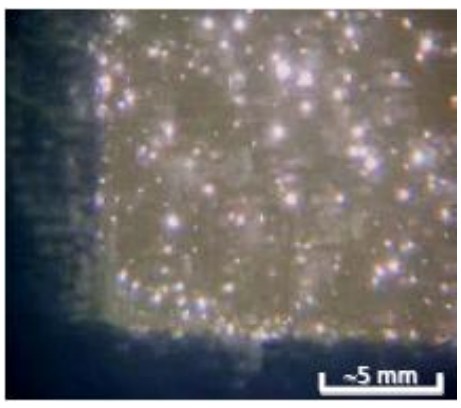
- Plasma electrolytic oxidation (PEO) of Ti can be used to prepare TiO_2 coatings with useful functional properties, such as photocatalytic and biological activity, for several applications, such as gas sensor and artificial joints.
- For dye sensitised solar cell (DSSC) applications, appropriate coatings are required to be porous and contain maximum amount of a metastable anatase phase.Anatase stabilisation requires approaches that are substantially different from those dominated in development of protective PEO coatings. One possibility consists in incorporation into the coating structure of anatase stabilisers.

Objectives:

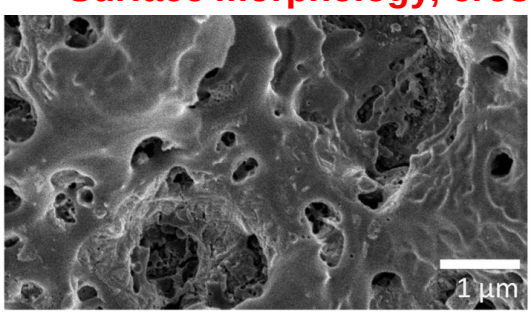
- For DSSC applications, appropriate coatings are required to be porous and contain maximum amount of a metastable anatase phase.
- Carry out the detailed microstructural observations and provide characterisation of the coating morphology at the 3 steps of coating formation and Maximizing the TiO_2 surface area for dye adsorption to enhance the DSSC efficiency.

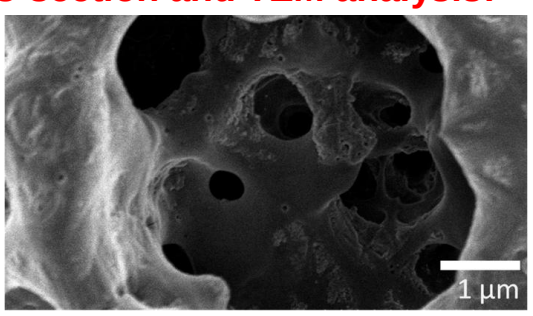
Plasma Electrolytic Oxidation (PEO) system and the sparking during PEO process:

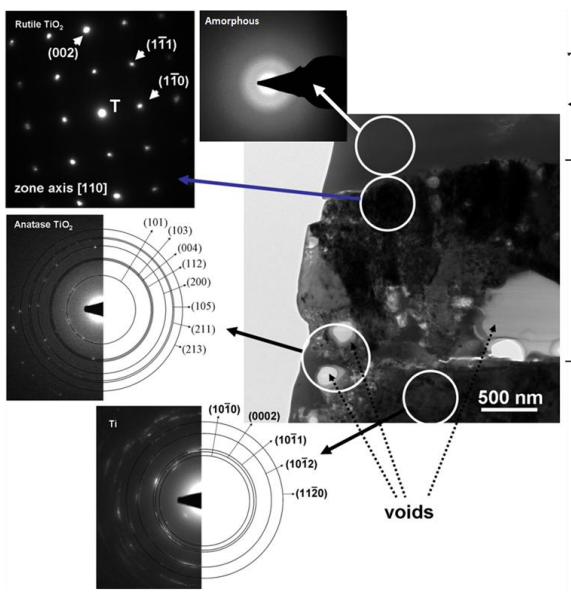




Surface morphology, cross-section and TEM analysis:

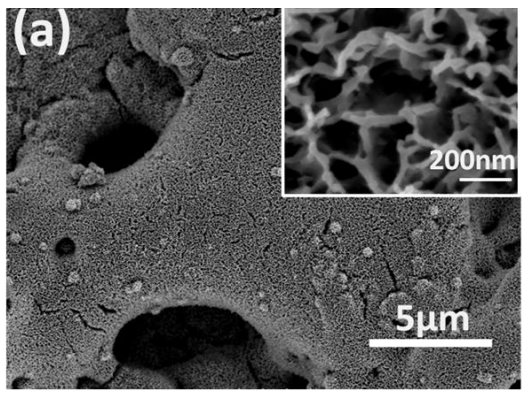


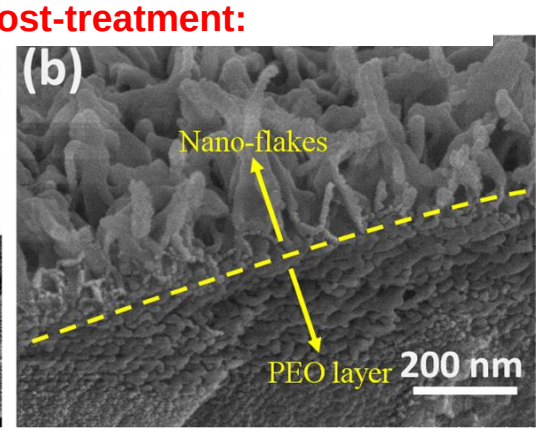


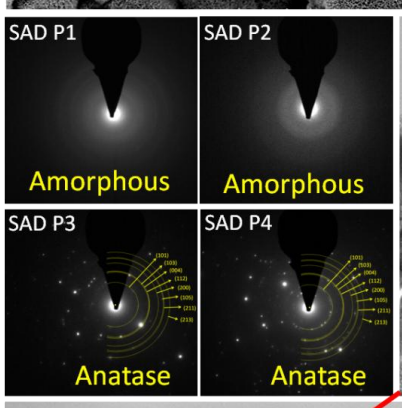


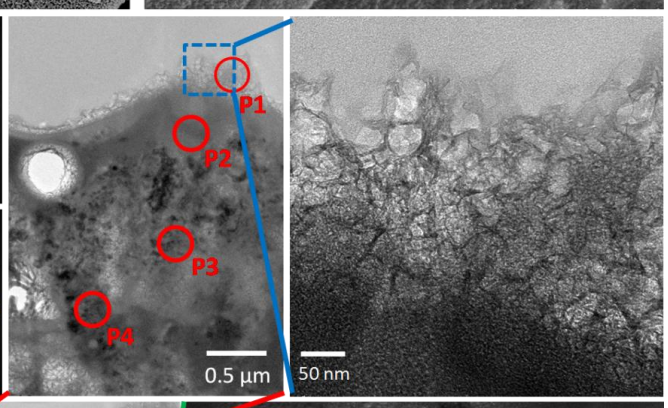
- The top amorphous layer is around one micrometer thick.
- A highly crystalline large rutile grain (about 500 nm in diameter) is located in the centre.
- A very large pore close to the substrate is found. Very fine anatase grains are around the periphery of large pore.
- The amorphous layer causes low efficiency of DSSC with less chance for reaction between dye and inner anatase.

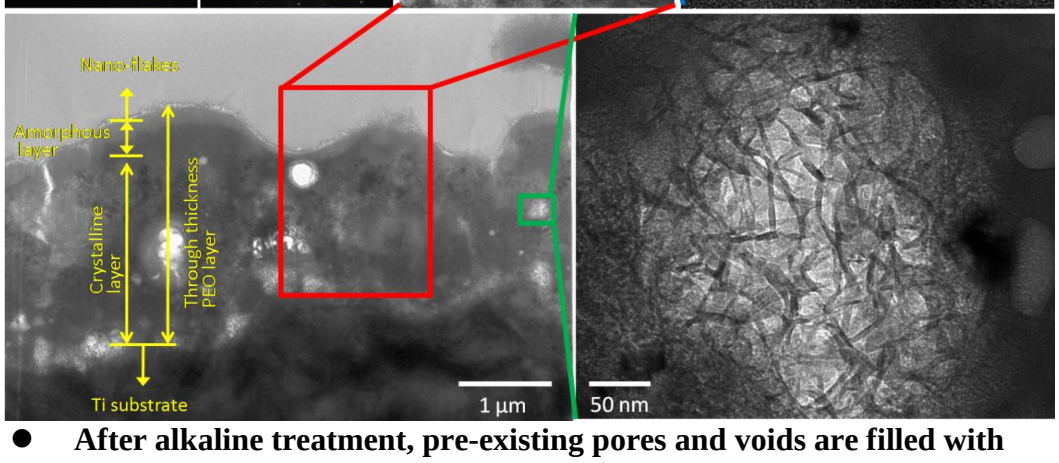
Surface morphology, cross-section and TEM analysis after chemical post-treatment:











- After alkaline treatment, pre-existing pores and voids are filled with nano-flakes.
- These 3D nano-flakes give rise to a significant increase in specific surface area, promoting photovoltaic efficiency
- The growth of nano-flakes occurred at the expense of the amorphous matrix, causing the thinning of the amorphous layer.

Achievements

- In this study, the NaH_2PO_4 produced coating comprises almost 100 % of anatase. This phase is appropriate for efficient reaction between titania and adsorbed dye during DSSC operation.
- Characterization has been carried out to PEO-TiO_2 coatings produced in phosphate electrolytes. The coating is successfully produced. It shows the most promising characteristics at thickness and surface morphology.
- Numerous small pores (200 – 300 nm in diameter) and several of big craters (1 – 2 µm in diameter) which full of nano-flakes are located in the surface and coating. This unique porous morphology provides the higher specific surface area, about 32 times to the flat thermal oxidized coating, which is beneficial for DSSC efficiency. The efficiency of DSSC is improved from 0.061 % to 2.194 % by using PEO-TiO_2 coating as electrode.

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