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Conversion of amorphous TiO2 coatings into their crystalline form using a novel microwave plasma treatment

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The photo-electrochemical splitting of water over metal oxides has been considered as a potential solar energy route for the production of hydrogen. Previous photocatalytic studies have largely focused on titanium dioxide (TiO_2) for water splitting due to its photostability and relatively low costs. In this study, both $TiO_2$and carbon-doped TiO_2 coatings were deposited using the closed field magnetron sputtering technique. The carbon-doped coating was deposited through the introduction of carbon dioxide into an argon/oxygen plasma during sputter deposition from a titanium target. The resultant coatings which were deposited onto glass and silicon substrates have an amorphous structure. A post-deposition heat treatment is therefore required to convert this amorphous structure into the photoactive crystalline phase of TiO_2. Furnace treatments are usually employed to achieve this conversion, but these treatments are comparatively time-consuming and energy-inefficient as processing times generally take over an hour. In this work, the use of a microwave plasma heat treatment is investigated for the first time as a means of achieving this crystalline conversion. This involved placing the coated parts into a 2.45 GHz microwave-induced plasma. It was observed that for treatment times of less than 1 minute, the 0.4-µm thick coatings were converted into the Anatase crystalline phase of TiO_2. This change was verified using glancing-angle X-ray diffraction. The coatings treated using the furnace and plasma treatments were compared using the following techniques: spectroscopic ellipsometry, SEM (including EDX and FIB), AFM, XPS, and Raman spectroscopy. In addition, the photocatalytic performance of the $TiO_2$and carbon-doped TiO_2coatings processed using the two heat treatments were also compared. A 10% increase in photocurrent density was achieved for the carbon-doped TiO_2compared to the un-doped coatings. It was concluded that the microwave plasma treatment represents a rapid and energy-efficient processing route for crystalline conversion and yielded metal oxide coatings with similar properties to those treated using the conventional furnace treatments.

Keywords
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