Control of active species in the afterglows of N_2 and N_2-O_2 microwave plasmas and the role of those active species in the selective surface nitridation of TiO_2 nanocrystals

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TiO_2 is widely used as a catalyst in various applications including photocatalysis, photovoltaics and sensors. However, the performance of TiO_2 is strongly determined by the detailed chemical structure of surfaces. So, the selective control of surface structure can be a good choice for the control of activities associated with it. As a one way to achieve such a goal, plasma treatments are widely used as in the case of enhancing the photoresponse of TiO_2 materials. Plasma treatments of TiO_2 have been used to enhance the visible light absorption for enhanced photocatalytic activity [1]. To understand the origin of enhancement, it is necessary to study the chemical states and bonding structure of the surface-modified TiO_2 materials.

In this study, anatase TiO_2 nanocrystals was exposed to the post-discharge region of N_2 microwave plasma and the chemical bonding states of surface nitrogen species on the surface-modified TiO_2 were carefully evaluated using X-ray photoemission spectroscopy (XPS) [2]. We observed that the surface treatments in the afterglows can induce stable nitrogen species which are formed at or near the surface of TiO_2. However, the detailed bonding configuration of N species can vary strongly depending on the type of active species present in the afterglow. Fig. 1 shows an example of N 1s core level spectra taken from the TiO_2 sample treated in the afterglows with N_2-O_2 microwave plasma. Here, it shows two distinct N species induced by the interaction of TiO_2 surface with the active species in the afterglow region. The high concentrations of O or NO in the afterglows of N_2-O2 plasmas can induce the formation of nitrate species in addition to the interstitial N species. In addition, a prolonged exposure in the early afterglow was found to induce addition N species at lower binding energies which is attributed to substitutional N species.

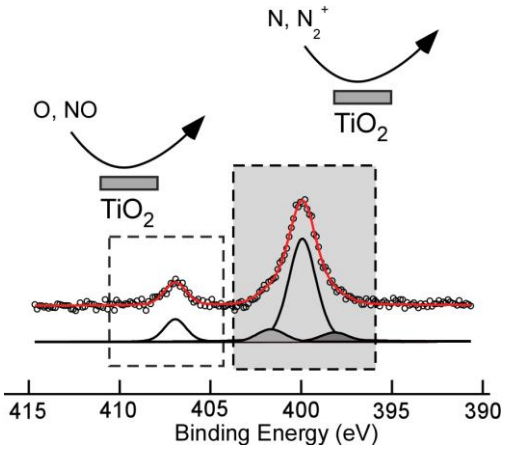

Fig. 1. N 1s core level spectrum of TiO_2 nanocrystals treated in the afterglow of N_2-O_2 microwave plasma showing different N species induced by different active species in the afterglow.

References:

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