Highly Efficient Mn-doped TiO_2 Film for Photocatalysis

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INTRODUCTION: In recent years, photocatalytic technology has been applied to various fields such as environmental purification, anti-bacterial uses, etc. For photocatalyst reaction of titanium oxide under indoor light, very weak light, say less than 380nm, has been useful, but photocatalytic efficiency using titanium oxide is not high. To increase the photocatalytic efficiency, we tried to extend the absorption end of the light to wavelengths over 380nm by adding a small amount of manganese to the titanium oxide.

EXPERIMENTAL: Titanium oxide precursor solution and manganese oxide precursor solution were prepared by advanced sol gel method. Titanium-manganese oxide mixture solution was prepared by mixing so that a molar ratio 10:1, 50:1, and 100:1 was obtained. The powders dried from the precursor solutions by IR lamp were heat-treated at various temperatures for 1 hour, and measured by X-ray diffractometer. As shown in Fig. 1, the peaks of titanium oxide assignated to anatase structure were confirmed at 500℃. When the amount of added manganese is increased, the anatase peak shifted to a larger angle. The peaks of manganese oxide were not detected. This result may be caused by the formation of a solid solution of titanium and manganese oxide.

Titanium, manganese and titanium-manganese oxide thin films were prepared by spin coating. UV-Visible absorption spectra of each thin film are shown in Fig. 2. When a small amount of manganese was added to the titanium oxide, the UV-Visible absorption spectra were almost the same as that of a titanium oxide only. But, by increasing the amount of manganese, the absorption end shifted to a longer wavelength. This result shows that manganese doped Titanium oxide thin film may be more useful to visible light portions of sunlight and indoor light than a titanium oxide only.

RESULTS: To check the photocatalytic ability of these films, we examined the amount of decomposition of an organic substance, methylene blue, by irradiation from a fluorescent light. The transmissivity change may correspond to the methylene blue decomposition by irradiation from a fluorescent light of which the ultraviolet rays were cut by a filter (DF-C and DF-M by Kenko Co. Ltd). The results are shown in Fig. 3. The photocatalyst activity of the titanium-manganese thin film of the molar ratio 10:1 was the highest.

A photocatalyst type solar cell was constructed using these manganese doped oxide thin films, and the photocurrent was measured under the irradiation of a fluorescent light with and without a filter to cut ultraviolet rays. At a molar ratio of titanium-manganese 10:1, the highest photocurrent was observed.

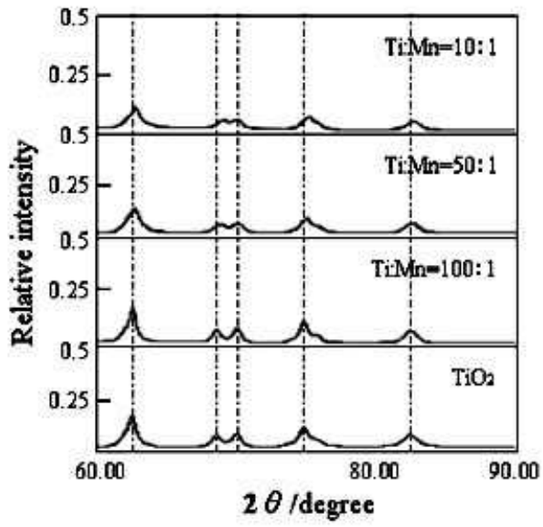

Fig.1 X-ray diffraction patterns of powder annealed at various molar ratio of Ti:Mn

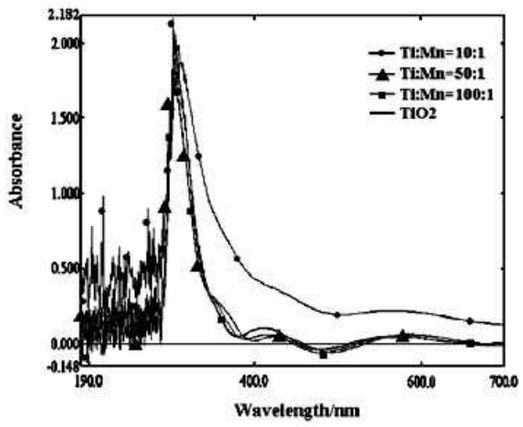

Fig.2 UV-Visible absorption spectra of each thin films

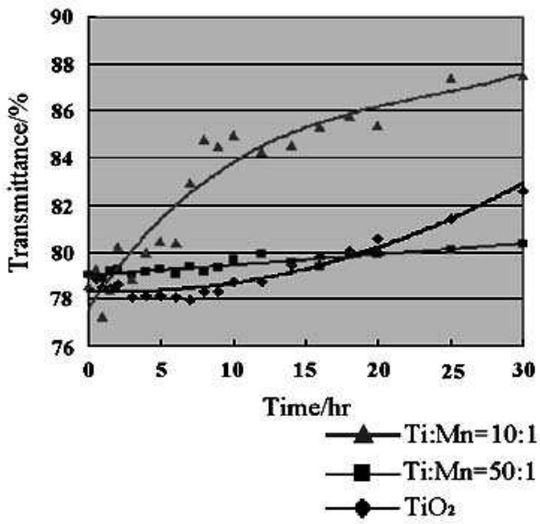

Fig.3 The methylene-blue decomposition by photocatalyst reaction using the fluorescent light filtered in the ultraviolet region