Advanced diffuse reflectance spectroscopy for the study of charge separation in Al-doped titania

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We report an experimental study of the separation, trapping and photo- and thermoactivated detrapping of charge carriers photogenerated in Al –doped titania by advanced diffuse reflectance spectroscopy. A liquid nitrogen cryostat and temperature-programmed annealing of the photoinduced absorption were applied to examine the physical processes occurring in the visible-light-responsive titania.

The Al –doped titania ceramic, synthesized by high-temperature (1145 K) oxidation of a titanium metal substrate in an air atmosphere, displays a strong photoresponse to irradiation in both the UV and visible spectral regions [1]. Irradiation results in the appearance of absorption bands (ABs) in the range 1.25–2.16 eV that are assigned to different Ti^{3+} centers. These ABs can be thermally annealed at $T \leq 550$ K [1]. The kinetics of the photoinduced absorption change $A_\lambda(t)$ at wavelength λ of the AB maximum under heating at a constant rate, plotted as dA_λ/dt *vs* T (temperature-programmed annealing spectrum), allows for the determination of the energy levels of charge traps [2].

A few titania ceramic samples differing in Al concentration were studied. It was found by means of diffuse reflectance spectroscopy that the samples have the same ABs, intensities of which increased with Al concentration. The processes of photo- and thermoactivated trapping/detrapping were found to be also similar. At the same time the resistance of the titania to reduction treatment was found to be higher for the samples with a higher Al concentration.

The results obtained show that the features-rich temperature-programmed annealing spectra provide a new quantitative and qualitative characterization of photoactive materials. These spectra permit probing the energy levels of electron and/or hole traps within the TiO_2 band gap.

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References

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