Investigation of dependence of charge carrier kinetics on the surface structure of hematite films

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Hematite, an inexpensive, earth-abundant and photo-stable material, has attracted a great attention because it can work as a photoanode of photoelectrochemical (PEC) cell for the water splitting. Many methods for fabricating hematite films have been reported so far. The surface structure of semiconductor materials has been studied, and it is strongly affected by the fabrication method. Although the structure significantly influences the behavior of charge carriers such as recombination or trapping processes[1], the dependence on the structure has not been understood enough.

We investigated the charge carrier kinetics of ALD (atomic layer deposition) and solution derived (SD) hematite films[2], possessing different surface structures[3, 4], using heterodyne transient grating (HD-TG) method. The HD-TG response of an ALD hematite film was measured in an aqueous solution, depending on the applied bias voltage, and presented in Fig.1. We could observe the decay of the recombination of ALD hematite (τ = 180 μs) was obviously slower than that of SD hematite (τ = 60 μs), indicating the charge separation efficiency of ALD hematite is higher than that of the SD one. However, the trapping dynamics of the long-lived holes to the deep state in the SD hematite was much faster (10^{-3} s) than that of ALD one (10^{-1} s), implying the difference of the deep states between ALD and SD hematite films. We believe it is a prime reason of the lower PEC performance of ALD hematite than that of SD one.

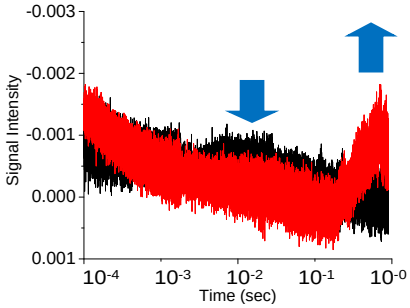

Fig.1 HD-TG responses of ALD (red) and SD (black) hematite films in aqueous solution, 1.4 V vs.Ag/AgCl

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