Development of visible light responsive TiO_2 photocatalyst with highly oriented gold nanoislands fabricated by PLD

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Localized surface plasmon resonance (LSPR) induced by the interaction of light with metal nanoislands (NIs) is well known for generating strong optical electric fields. By utilizing the technology, a visible light-responsive photocatalyst was developed [1], therefore, it is expected to contribute to environmentally friendly devices such as deodorizing, sterilizing and water splitting. In order to provide the photocatalyst, a simple method for fabricating gold-NIs with strong optical electric fields is required. Recently, highly oriented gold NIs (HOG-NIs), showing optical electric field enhancement (over 10^7) and resonation with wide range of light (550 nm to 900 nm) were developed by a simple pulsed laser deposition (PLD) method [2]. Thus, we tried to fabricate visible light-responsive photocatalyst material by combining titanium dioxide (TiO_2) and HOG-NIs.

HOG-NIs were fabricated on magnesium oxide (MgO) (001) substrates by using a PLD. The MgO substrate and a gold target were placed in a vacuumed chamber (pressure 10^{-6} Pa). The substrate was heated (outgas: 350 ˚C for 30 min, cleaning: 850˚C for 30 min) by a silicon carbide heater. Ablation plumes were generated from a laser spot on the gold target by irradiating a pulsed laser beam (LOTIS TII, LS-2147, wavelength : 355 nm, pulse width : 12 to18 ns, laser fluence : 0.8 J/cm^2, number of pulses : 7000). HOG-NIs was obtained by depositing the ablation plumes on the MgO substrate. As a reference, we prepared gold NIs fabricated by a sputtering method. After gold deposition on MgO, TiO_2 was deposited on the HOG-NIs by a spin coating method (solution: Pexel Technologies, PECC-C01-06).

Figure 1 are surface images of HOG-NIs, gold-NIs and TiO_2 taken by atomic force microscopy. HOG-NIs showed a tetragonal shape whose size were less than 100 nm (see Fig. 1a). It can also be confirmed that they were aligned along the [011] direction of MgO(100). On the other hand, normal gold-NIs were observed at gold-NIs fabricated by the sputter method (see Fig. 1b). The shape of TiO_2 were porous (see Fig. 1c). In our presentation, we will discuss the photocatalytic reactions of samples.

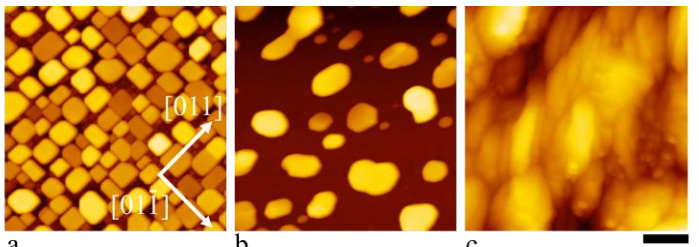

Figure1

References: [1] X. Shi, K. Ueno, T. Oshikiri, Q. Sun, K. Sasaki et al, Nat. Nanotechnol., vol. 13, p. 953 (2018).
[2] S. Kurumi, K. Sugawa, K. Takase, Y. Darma, T. Sagara, et al, Appl. Phys. Lett., vol.123, p. 053502 (2023).