18p-D4-1

Surface plasmon assisted IR transmission switching on Au nano-particles embedded VO_2 thin film

Takuo Tanaka

[1] Metamaterials Laboratory, RIKEN and [2] RIES Hokkaido University
E-mail: t-tanaka@riken.jp

1. Introduction

Vanadium dioxide (VO_2) is known as a phase transition material that changes its material phase between metal-phase and insulator-phase by external stimulations such as temperature, light irradiation and so on. The phase transition accompanies very steep changes of electric conductivity and light transmittance. In this study, Au nanoparticles (AuNPs) embedded VO_2 thin film was made, and surface-plasmon-induced phase transition of VO_2 was experimentally investigated.

2. Experimental measurement of basic properties of VO_2 film with AuNPs.

VO_2 has the critical temperature of its phase transition around at 68 °C. It shows insulator phase under the critical temperature and metal phase above it. We made a Au NPs embedded VO_2 thin film. AuNPs whose diameter were 20 nm were adsorbed on a glass substrate. VO_2 thin film whose thickness is 60 nm was deposited by reactive sputtering method in O_2 and Ar mixed gas.

We measured the transmission spectra of the sample. The AuNPs embedded VO_2 film showed a low transmission band at wavelength of 620 nm. Since this band did not appear in that of bare VO_2 film, we supposed that the origin of this low transmission band came from the absorption of the plasmonic resonance of the AuNPs.

Figure 1 shows the temperature dependence of the transmittance of infrared (IR) light (λ=1550 nm) with and without irradiation of red light (λ=635nm). The blue curve shows the result of without red light irradiation. The transmittance drops around 66 °C. This is the intrinsic critical temperature of VO_2. When the red light of 10.3 mW was irradiated on the VO_2 film overlapping with the IR-light, the critical temperature decreased to 61°C as shown by red hysteresis curve.

From the result, we suppose that the plasmonic resonance of the AuNPs was excited by the red light irradiation, and strongly enhanced electric field triggered the metal-insulator transitions of VO_2 and the critical temperature was decreased.

3. Surface plasmon assisted IR transmission switching

The temperature of the sample was kept at 60 °C and the IR light (1550nm) transmittance was measured with turn-on and off of the red light irradiation. The result is shown in Figure 2. The red curve in the Fig. 2 shows time-varying of the transmittance of the IR light. When the red light was turned on, the transmittance was dropped 3% immediately. This decrease of the transmittance was kept even after the red light was turned off. This result indicates that the AuNPs embedded VO_2 film act as a latch type switch for IR light controlled by the red light irradiation. This phenomenon was not found in the bare VO_2 film.

This result can be explained as follows. When the temperature is kept at 60 °C, the state of the sample is at the position α on the hysteresis curve of blue in Fig. 1. When the red light is irradiated on the film, the state moved to the position β as the green arrow. Since the position β is the stable point for hysteresis curve of blue line, even after the red light is turned off, the state of the film does not change and this makes the latch type switching of the IR light.

In the presentation, we will also present about the intensity and wavelength dependences of phase transition of AuNPs embedded VO_2 films.

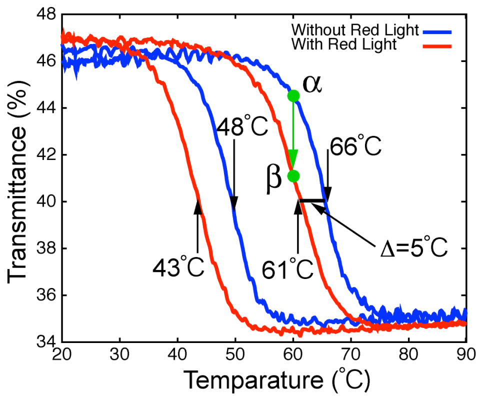

Figure 1. Temperature dependence of the transmittance of IR light of AuNPs embedded VO_2 film.

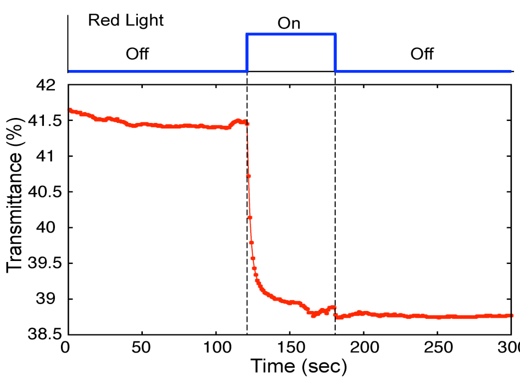

Figure 2. IR light switching by the red light irradiation on the AuNPs embedded VO_2 film.