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Metallic photo-monitors for optical waveguides at telecom wavelengths

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1. Introduction

The absorption of light at metal surfaces are not negligible at optical wavelengths. Thus, by taking advantage of the optical absorption of metals as well as their electrical conductivities, one could design metallic photodetectors for optical waveguides.

Metal-insulator-metal (MIM) structures are one of the simplest structures to extract photo-exited hot electrons. In the present work, we experimentally show that an MIM contact attached to an optical waveguide can detect telecom wavelengths.

2. Experiment and results

In the experiment, we prepared a polymer waveguide with SU-8, which is a negative-tone photoresist. Gold (Au), titanium dioxide (TiO_2) and titanium (Ti) thin films were subsequently sputtered to form a MIM structure on the waveguide. The schematic illustration of the cross section is shown in Fig. 1(a). In order to leave single-layer areas for contacts, shadow masks are used. The thicknesses of the gold layer was 25 nm, so as to have sufficient absorption to generate hot carriers, and at the same time thin enough for hot electrons to reach to the Au-TiO_2 interface. The thickness of the TiO_2 layer was 10 nm, which was thin enough for the hot carriers to traverse. The photo-responses of the sample were measured by a home-made waveguide alignment setup [1,2].

Figure 1(b) shows the photo-response of the fabricated device at the wavelength of 1310 nm and 1550 nm. The bias voltage was applied between the titanium dioxide layer during the measurements. Photo-induced currents were observed at the both wavelengths.

An important difference between caused by the two wavelengths is the short circuit current. While the photocurrent at zero bias is positive at the wavelength of 1310 nm, the photocurrent at zero bias is zero at the wavelength of 1550 nm. The reason can be explained by the photon energy with respect to the energy barrier. The electronic barrier height at Au-TiO_2 interface is about 0.9 eV (1378 nm) and the interface at TiO_2-Ti is considered to have much lower barrier or nearly ohmic [3]. Thus, hot electrons excited at 1310 nm can cross the barrier without bias, however, hot electrons excited at 1550 nm do not have sufficient energy to cross the barrier at zero bias.

When the bias is applied, hot electrons excited at 1550 nm can also cross the barrier, but the probability of hot electrons to reach to the other side is still higher at 1310 nm. This is also seen in Fig. 1(b) that the magnitude of photocurrent is larger at 1310 nm when the magnitude of the bias is large.

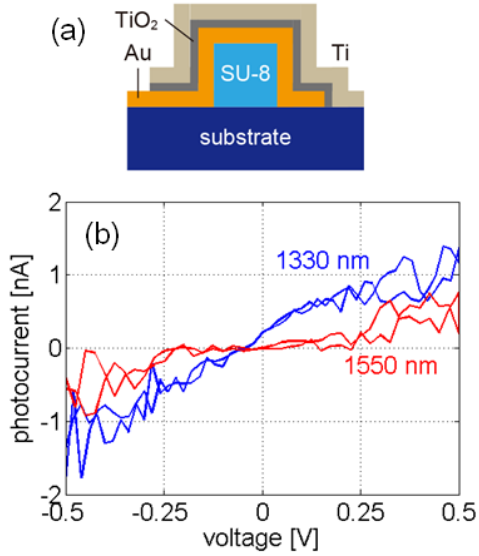

Fig. 1. (a) Schematic cross section of the fabricated device. Not to scale. (b) Photo-response of the MIM contact consists of Au-TiO_2-Ti layers by guided light along the SU-8 waveguide. The input powers at 1310 nm and 1550 nm were fixed at 1.75 mW.

3. Conclusions

To summarize, we experimentally demonstrate that the MIM contact can detect telecom wavelengths guided along an optical waveguide.

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