Photoabsorption and Photoelectric Conversion Properties of InP Porous Structures Formed by Electrochemical Process

T. Sato, Y. Kumazaki, R. Jinbo and Z. Yatabe
Research Center for Integrated Quantum Electronics, Hokkaido Univ., N-13, W-8, Sapporo 060-8628, JAPAN
E-mail: taketomo@rciqe.hokudai.ac.jp

Among the various approaches for forming semiconductor nanostructures, the electrochemical process is one of the most promising processes due to its unique features. We have recently reported that extremely low reflectance below 0.4% was observed from the electrochemically-formed InP porous nanostructures in UV, visible, and near-infrared ranges [1]. In this paper, we investigated the photoabsorption properties of InP porous structures using photoelectric conversion (PC) devices formed on p-n junction substrates.

The device structure and experimental setup are schematically shown in **Fig. 1**. This device has the porous structure formed in the n-type InP layer (n=8x10^{17}cm^{-3}) grown on the highly-doped p-type substrate. The porous structure was electrochemically formed using a standard cell using the electrolyte [2]. To supply current, the AuZn/Ni-ohmic contact was first made on the backside of the p-type InP substrate. The anodic bias, V_a, and anodization time, t_a, were set at 7 V and 5 s, respectively, to form the porous structures only in the n-type layer. After the formation of the porous structures, the sample was partly etched to a convex shape, in which the GeAu/Ni ohmic contacts were formed. In this study, the photocurrents, I_1, shown in **Fig. 1** are measured under various light conditions using an Ar$^+$ ion laser with a wavelength of 514.5nm.

Only the photo-carries generated near the p-n interface are separated by the electric field in the depletion layer and collected to the electrodes. The photon flux at the p-n interface, Φ, is represented by the following equation.

$$\Phi = \Phi_0 \exp(-\alpha d_{top}), \qquad (1)$$

where α is the absorption coefficient, d_{top} is the thickness of the top layer, and Φ_0 is the incident photon flux. Since the photocurrents observed in this device are assumed in proportion to the photon flux, Φ, the response of the current, I_1, give us the information on the photo-absorption properties of the top layer shown in **Fig. 1**. Namely, the observed photocurrents decrease as the absorption coefficient and thickness of the top layer increased.

Figure 2 shows the current response of a porous PC device to the incident light at various power levels, P_{IN}. We found that the photocurrents increased with the P_{IN} in quick response to the light switching. To clarify the photoabsorption properties of the porous structure, the ΔI_1 are compared with the non-porous devices in **Fig. 3**, plotted as a function of the P_{IN}. Both the non-porous and porous devices showed a similar behavior, the ΔI_1 linearly increased with P_{IN}. The correlation coefficients obtained by linear fitting on the experimental data were greater than or equal to 0.998. However, the current value differed substantially, where the photocurrent of the porous device was approximately 40 % that of the non-porous device. As mentioned above for Eq. (1), a low photocurrent indicates a high absorbance in the top layer since the photocarriers generated near the p-n interface decreased exponentially with an increase in the absorption coefficient, α. These results suggest that the absorption coefficient of the porous layer is higher than that of the non-porous layer.

We also fabricated the novel photoelectric conversion devices that have the p-n interface on the InP wall inside pores. The photocurrents generated at the pore interface were extremely larger than that obtained on the planer interface (not shown here). We believe that the porous structure is promising materials for use in photoelectric conversion devices due to their unique features such as their large surface area and high photoabsorption properties.

[1] T. Sato et al.: Thin Solid Films, **518** (2010) 4399.
[2] T. Sato et al.: Appl. Surf. Sci. **252** (2006) 5457.

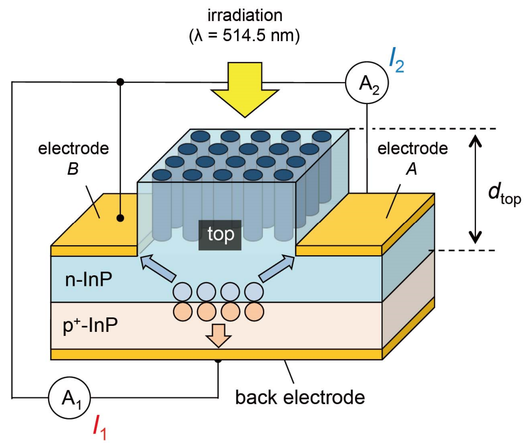

Fig. 1 Schematic illustration of device structure and experimental setup.

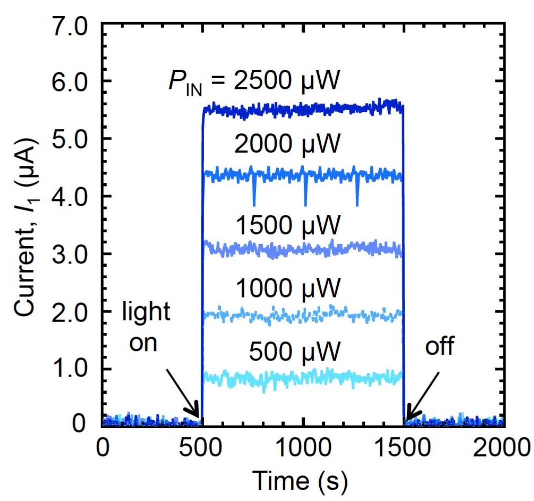

Fig. 2 Current response properties of porous PC device based on incident light at various power levels, P_{IN}.

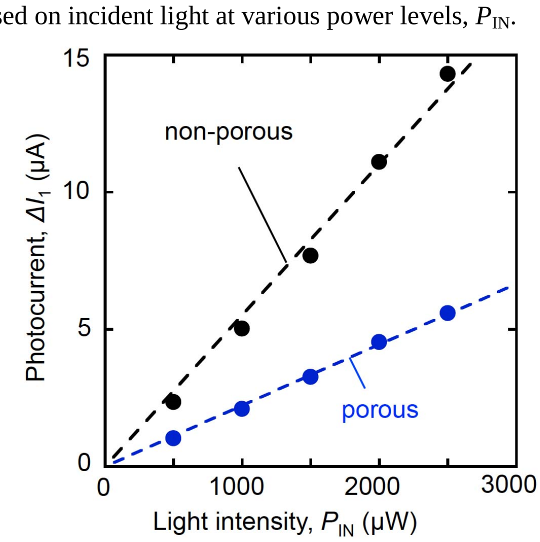

Fig. 3 Comparison of photocurrents between non-porous and porous devices plotted as function of P_{IN}.