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B-7-4 Integrated Photodetector Using the Partially Metal-Clad-Dielectric-Slab Waveguide Structure

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1. INTRODUCTION In various active devices of integrated optics, metal electrodes are usually indispensable. In connection with electrodes, the partially metal-clad-dielectric-slab waveguide (PMC line) structure has advantages over other waveguides(1). It is because that metal claddings used in the PMC line can serve not only to confine the light waves two dimensionally, but they can also serve as metal electrodes. In this paper, an integrated photodetector using the PMC line structure is proposed with some experimental results.

2. PRINCIPLE OF OPERATION Figure 1-(a) shows schematically the structure of the proposed photodetector. Since the effective index of refraction of the dielectric-clad region (region 1) is higher than that of the metal-clad region (region 2), a light incedent to the PMC line is confined two-dimensionally (x- and y-direction) and distributes mostly in the dielectric-clad part of the core. The guided wave is, then, transferred to a tapered coupling layer whose permitivity ε_3 is larger than that ε_2 of the core. When a guided wave reaches the detecting part, which has either a photovoltaic or photoconductive layer, light enery is converted to an electrical signal. In the detector of Fig. 1-(a), a silicon Schottky diode using a semi-transparent gold film acts as a photovoltaic layer.

3. EXPERIMENT A cross section of the detecting part is indicated in Fig 1-(b). After fabricating the PMC line by the methode described previously(1), the coupling layer is formed with an organic compound. Then, Si-Schottky diode, which was constructed by depositing a semi-transparent gold film (200-300 Å) on an n-on-n^+ silicon epitaxial wafer , is bonded with its face down on the coupling layer. The thin gold film is connected by conductive paints with the metal cladding which works here as an electrode ; an ohmic contact to the silicon wafer is made on the n^+ side of the wafer.

Figure 2 indicates the current-voltage characteristics of a fabricated photodetector. Note that the device is photosensitive, when reverse-biased.

Figure 3 shows a detected waveform of He-Ne laser light of 6328Å modulated by a chopper. The reverse-biase of the detector is 6V. A TM_0 wave is excited in the core of the dielectric slab waveguide by a prism coupler, and led to the detecting part.

4. DISCUSSION The coupling of the light from the coupling layer through the very thin gold film to the depletion layer of the diode is similar to the coupling of an ordinary film-prism output coupler in which coupling takes place via an air gap. This similarity suggests and the rigorous analysis shows that the coupling can be controlled by choosing the thickness of the gold film and the coupling layer and the length of a photodiode properly.

The present integrated photodetector has such advantages as : (*1*) ease of the fabrication, owing to use of the hybrid-integrated-circuit technique, (*2*) good performance at high frequencies, owing to the small dimension of the detecting part (a device with an active region of 50μm×200-300μm can operate efficiently without using lense.), (*3*) potentiality to be used in various integrated circuits such as detector arrays.

(1) J.Hamasaki and K.Nosu, IEEE J.of QE, QE-10, p.822 (oct.1974)

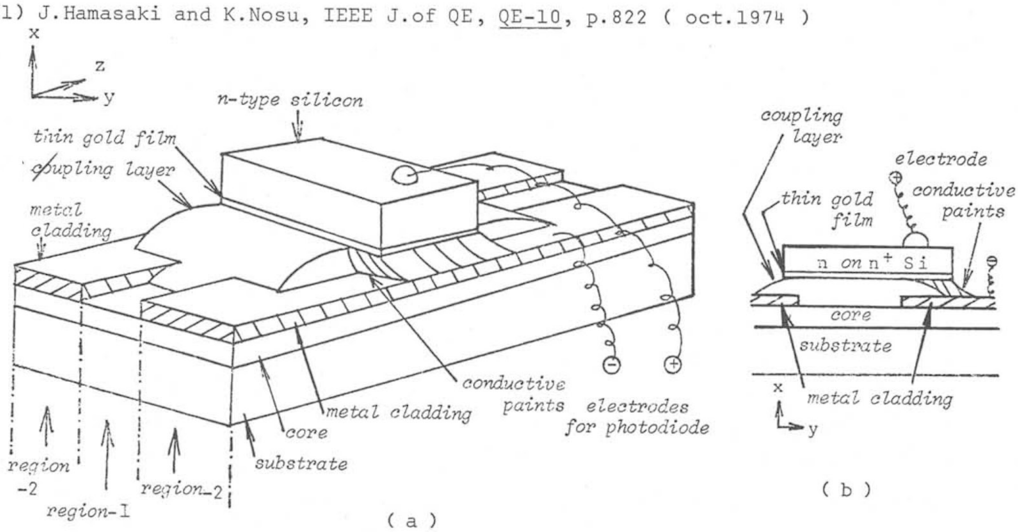

Fig.1 Schematic structure of detector. The substrate, the core, the metal cladding are Pyrex glass ($\varepsilon_1=1.47^2$), a sputtered Corning 7059 glass film ($\varepsilon_2=1.57^2$, 2μm thick) and a eavaporated aluminium film (0.1μm thick), respectively. The gap of the metal claddings are 50-80μm.

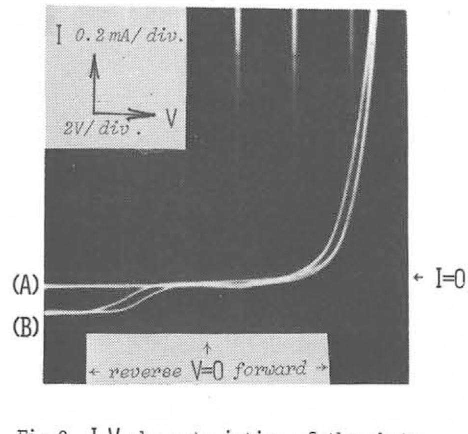

Fig.2 I-V characteristics of the photodetector when placed in the dark (A) and when illuminated (B).

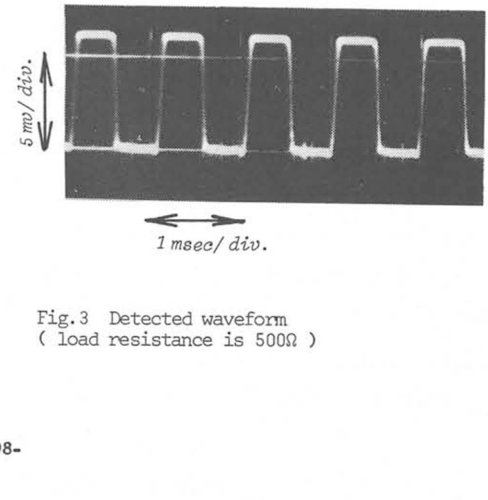

Fig.3 Detected waveform (load resistance is 500Ω)