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Numerical Analysis of Enhanced Photodetector in Terahertz Spectrum

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ABSTRACT— We report numerical analysis based on finite element method to characterize the performance of photodetector in terahertz band. In this paper based on the Fabry-Perot cavity rules, we propose an enhanced photodetector, which Au rods and Au film constitute its cavity. To have optimizing cavity, we investigate the geometrical parameters on absorption spectrum. Our calculation shows that the absorption can be enhanced by about 55 times in the active region of terahertz photodetector compared to conventional photodetector without metallic cavity.

KEYWORDS: Fabry-Perot cavity, Finite element, Photodetector, Terahertz.

I. INTRODUCTION

Optoelectronic devices have wide applications in the new generation of electronic and communication systems. The ability to design of high speed, low noise and broadband systems has provided sufficient incentive to use these devices [1]–[2]. Among them, photodetectors are more important and infrared photodetectors are interesting components in optical communications, thermal imaging and sensor networking [3] – [4]. There are various types of photodetector which used in a wide range of the electromagnetic spectrum from sub-millimeter radiation to the visible region we perceive as light. Terahertz (THz) rang of electromagnetic spectrum has recently emerged as an important topic of scientific investigation [5]. THz detectors are one of the key devices in various THz applications. Quantum cascade, quantum well and quantum dot infrared photodetectors are devices that exploit intersubband absorption between the first two subbands or bound to-quasi-continuum to realize terahertz detection [6]. Due to loss of free carrier absorption and low thickness of active region, optical absorption is low therefore the performance of photodetector is week. These issues can be avoided by using optical enhancement approaches, such as the use of a Fabry-Perot resonant cavity. With a resonant cavity, it becomes possible to increase the detector efficiency many times by greatly extending the interaction length between the incoming light and the active material.

Resonant cavity enhanced photodetectors have attracted much attention due to the ability of high quantum efficiency, wavelength selectivity, and a high speed response. The resonator system we present here is composed of Au rods as top reflector and Au film as bottom reflector. This structure compensates the loss of incoming light and doesn't need to increase the active layer thickness.