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Impact of silver nanogratings for enhanced light absorption in plasmonic based photodetector

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ABSTRACT

Recent era has witnessed a wide interest of researchers for the development of nano scale high speed photodetectors. Now days, optical communication systems demand these detectors with light enhancement along with high gain and bandwidth. Plasmonics based photodetectors with gold nanogratings are employed in literature for high responsivity and miniaturization. However, these devices need to be explored for other metals as gold being very costly. In this work, plasmonic based photodetector is designed with silver nanogratings and analyzed over varying shapes like rectangular, trapezoidal, ellipse and parabolic taper. Enhanced light absorption with quenching factor of 73.96% is achieved with rectangular grooves in near infrared region as compared to other shapes.

1. Introduction

Plasmonics is a new emerging field to bridge the bottle neck between electronics and optical devices. Phenomenon of light trapping due to strong interaction between light and metal surface at nano-scale has led to an improvement in the light absorption with subwavelength aperture [1]. Plasmonic based photodetectors operate in the near-infrared range from 0.8 to 1.6 μm and considered as promising candidates for upcoming optoelectronic systems [2], high-speed optical communication systems, high-speed chip-to-chip interconnects and high-speed sampling [3,4]. Subwavelength plasmonic nano-structures device has been proposed by various researchers for better utilization of bandwidth in optical communication [5].

Plasmonic based photodetectors (PDs) can utilize the concept of subwavelength plasmonic nano structures for high response and better sensitivity [6–8]. In this nanostructure design, electromagnetic (EM) field confinement occur at nano-scale as compared to other focusing methods like dielectric lens etc. [9,10]. Fig. 1 shows the structure of conventional metal semiconductor metal photodetector (MSM-PD) which consists of two electrodes (metal contacts) present on the metal surface and GaAs (gallium arsenide) as substrate [22]. These metal contacts act as schottky diode. By applying input voltage, electron-hole pairs are created leading to output current i.e. photoelectric current [18].

The major drawback associated with this structure is that when light is incident on the metal surface maximum light is reflected back leading to less light absorption as compared to reflection [18,19]. To overcome this problem new structure design which is plasmonic based single layer photodetector came into existence with nanogratings of different shapes to achieve the maximum light absorption as shown in Fig. 3.

These photodetectors are analyzed with input wavelengths and noble metal like gold (Au) [15–19] but literature lacks with design and analysis of plasmonic based MSM-PD for other noble metal like silver for maximum light absorption enhancement factor (LAEF).

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