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QWIP Focal Plane Array Theoretical Model of 3-D Imaging LADAR System

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Abstract—The aim of this research is to develop a model for the direct detection three-dimensional (3-D) imaging LADAR system using Quantum Well Infrared Photodetector (QWIP) Focal Plane Array (FPA). This model is employed to study how to add 3-D imaging capability to the existing conventional thermal imaging systems of the same basic form which is sensitive to 3–5 μm (mid-wavelength infrared, MWIR) or 8–12 μm (long-wavelength infrared, LWIR) spectral bands. The integrated signal photoelectrons in case of short integration time is required to transmit laser pulses with higher energy in order to obtain photoelectrons nearest those values obtained from the background photoelectrons in thermal imaging system with the longer interval of time. Since the operating conditions of the proposed system are of low levels for speckle diversity and high levels of signal photoelectrons, it was shown that the signal obeys the Gaussian probability density function. The evaluation of system performance of the proposed model shows that it needs a detector with low dark current and high transmitted energy to obtain satisfactory parameter values.

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1. INTRODUCTION

The technology of band gap engineering has led to significant advances in the development of new infrared photodetectors (IR). In a bulk type of semiconductor materials, electrons are free to move in any of the three spatial directions. A confining structure may be made by embedding a limited region of one material within another. The difference between allowed electronic states for the two materials forms a barrier to free electron movement. If any dimension of the structure approaches the wavelength of an electron, quantum effects will arise. Quantum structures of semiconductor materials have the property of confining the mobility of electrons.

Each one of three dimensions of the bulk material may be thinned conceptually to yield three classes of quantum structures. Making the structure thin along the first axis results in a two dimensions layer called a quantum well. If thinned along a second axis, a one-dimension quantum wire is produced. Thinning along the final axis leads to a zero dimension structure known as quantum dot.

The seed of quantum well devices was planted since the suggestion that a heterostructure consisting of alternating ultrathin layers of two semiconductors with different band gaps should exhibit some novel useful properties [1, 2]. The band-edge potential varies from layer to layer due to the difference in the band gaps, and a periodically varying potential is produced in the structure with a period equal to the sum of the widths of two consecutive layers [3]. This is because of the importance of the developed device in achieving novel characteristics in the fields of optical communications, thermal imaging, and sensor networking, etc. Recently IR photodetectors have been the focus of much attention due to their potential uses in far-infrared imaging as well as room temperature operation, which is of interest from user's point of view.

Quantum well infrared photodetectors (QWIP) have been developed very quickly and demonstrated large format focal plane arrays with low noise equivalent irradiance, high uniformity, and high operability. Using high quality GaAs material systems, QWIPs have the potential for high production with low cost and low power consumption.

On the one hand, infrared focal plane array (IRFPA) technology is very important to ballistic missile defense (BMD) and space-based applications, as well as other military and commercial applications. These arrays are widely used in tactical applications for surveillance, target detection, target tracking, and discrimination. On the other hand, important FPA characteristics for future BMD FPAs will include large