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Optical gain analysis of GaInP/AlGaInP nanoscale heterostructure for applications in visible light emission

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ABSTRACT

In quantum well structures, charge carriers are confined in the well region and barrier region due to the discontinuity in the bandgap and larger built-in potential. Thus, for a smaller current, we can have a higher gain. This work reports the energy wavefunction and optical gain analysis of the GaAs-based quantum well structure made of GaInP/AlGaInP material layers. The structure is also examinedsubject to the effect of external pressure and temperature to study the tunability. The designed structure shows stability near the room temperature. The 6 × 6 Hamiltonian matrix is solved and the Luttinger-Kohn model with the conduction band is used for the calculation of band structure. In the quantum well structure, the thickness of the active layers is in our control. This is an important advantage for device fabrication. The material and the size of the layers are selected on the basis of their suitability to generate the radiation in the range of the red spectrum (620-–750 nm).The designed QW heterostructure is thus found to be suitable for photodynamic treatment (PDT) and dermatological treatments.

Selection and peer-review under responsibility of the scientific committee of the 3rd International Conference on “Advancement in Nanoelectronics and Communication Technologies”.

1. Introduction

In today’s era optoelectronic devices like the Photodetectors (PDs), light emitting diodes (LEDs), laser diodes (LDs)and optical waveguides and sensors are widely utilized in the field of optical fiber communication, medical science for the diagnosis of diseases, automobile industries and spectroscopy for pollution monitoring and food safety and quality control [1–4]. This growth of the optoelectronic components industry is mainly expected by the increased use of visible range and infrared components due to the long life, cheap & low power consumption demand. Robert N. Hall created the first laser diode device in 1962, which was built of gallium arsenide and radiated at 850 nm in the near-infrared range [5]. The first semiconductor laser with visible red-light output was presented by Nick Holonyak, Jr. [6]. Herbert Kroemer (1963) presented the heterojunction laser for the first time [7]. He suggested that the introduction of heterostructure could promote population inversion. The heterostructure is the interface of two dissimilar materials with different bandgap energy.Recently, the optical sources working in the visible spectrum range (400–750 nm) and in the near-infrared (780–2500 nm) region have been studied theoretically for the optimization of device performance [8–12]. Optical sources operating in the near-infrared (NIR) region find applications in spectroscopy [13] and optical fiber communication [14,15]. Far infrared lasers are used in Terahertz spectroscopy [16]. GaInP/AlGaInP single heterojunction solar cells on GaAs substrate have been extensively examined recently [17].An optical source working in the visible spectrum is widely utilized in medical science for diagnosis of the disease and CD writing [18–19]. Researchers and scholars are more involved these days on the utilization of lasers in medical application for growth therapy, cancer therapy, and the treatment of skin infections [20]. Around half of the instances of disease are treated with radiation in blend with a medical procedure. The radiation treatments which are generally utilized are photodynamic treatment (PDT) and interstitial Photodynamic Therapy (iPDT). PDT uses a photosensitizer drug which is infused with a specific frequency of light that the body cell will absorb. The power of a laser in medical application is a limiting factor which depends on the type of disease. For PDT and dermatological treatments, lasers with a wavelength range of 630–740 nm are suitable and widely utilized. The red

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