MODELING AND OPTIMIZATION OF PROPERTIES OF GA2O3-BASED QUANTUM STRUCTURES IN ORDER TO ACHIEVE HOLE CONDUCTIVITY

T. Gagnidze[1,2,3,a*] , D. Kobaidze[1], L. Burdiladze[1], N. Basharuli[1], E. Chikoidze[4], T. Davitashvili[1], H. Meladze[5], T. Tchelidze[1]

[1]*Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[2]*AndronikaShvili Institute of Physics, Tbilisi, Georgia*
[3]*Chavchanidze Institute of Cybernetics, Tbilisi, Georgia*
[4]*Groupe d'Etude de la Matiere Condensee (GEMaC), Universite de Versailles Saint Quentin en Y.-CNRS, Universite Paris-Saclay, 45 Av. des Etats-Unis, 78035, Versailles Cedex, France*
[5]*Muskhelishvili Institute of Computational Mathematics, Tbilisi, Georgia*
[a]*tornike.gagnidze@tsu.ge*

Abstract: In this project, we investigate the properties of Ga_2O_3-based quantum structure with the aim of improving hole conductivity in the oxide. Ga_2O_3 is a promising material for electronic and optoelectronic applications due to its ultra-wide band gap and high breakdown voltage. However, its low hole mobility and concentration limit its performance in some applications. Recent studies have shown that Ga_2O_3 thin films can exhibit surface p-type conductivity under certain growth conditions. In this work, we use the finite-element method to model the electronic properties of Ga_2O_3 quantum well with triangular potential barrier. Our results provide insights into the design and optimization of Ga_2O_3-based quantum structures for improved hole conductivity in the oxide.

1. Introduction:

Gallium oxide is a ultra-wide band gap semiconductor material that has attracted increasing attention for its potential use in electronic and optoelectronic devices due to its high breakdown voltage and optical transparency in the visible to ultraviolet region. However, its low hole mobility and concentration limit its performance in certain applications. Recently, surface p-type conductivity has been observed in Ga_2O_3 thin films grown under specific conditions, which provides a promising pathway to improve its hole conductivity[1,2].

In this project, we use the finite-element method to model the electronic properties of Ga_2O_3-based quantum structures with triangular confinement potential. The triangular potential well is a widely adopted geometry due to its similarity to the potential profile observed in quantum heterojunctions, for instance the modulation-doped AlGaAs-GaAs heterojunction, for electrons confined within GaAs[3]. Our investigation aims to understand the impact of this confinement potential on the electronic structure of Ga_2O_3-based quantum structures, and how it can be optimized to enhance their hole-concentration and mobility.

In our study, we solved the Schrödinger equation with triangular potential using the WKB (Wentzel-Kramers-Brillouin) approximation, which is a method used to obtain approximate solutions to quantum mechanical problems [4]. Additionally, we developed a finite-element method to tackle the triangular barrier with a finite wall, which is a more challenging problem. Additional, we take into account the presence of impurities, which are known to affect the electronic properties of semiconductor materials.

By employing these methods, we were able to gain insights into the electronic properties of quantum structures with triangular confinement potentials. Our findings can guide the experimental efforts towards developing high-performance electronic and optoelectronic devices based on Ga_2O_3.

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