DONOR STATES IN A $GaAs/Ga_{1-x}Al_xAs$ QUANTUM WELL WIRE OF CIRCULAR CROSS SECTION

By

Hannington Odhiambo Oyoko

B.Sc. University of Nairobi, Kenya, 1974

M.S. Fairleigh Dickinson University, New Jersey, 1987

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

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(in Physics)

The Graduate School

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May, 1991

Advisory Committee:

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Date April 9, 1991.

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Thesis Advisor: Peter Csavinszky, Ph.D.

An Abstract of the Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (in Physics).

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The present work considers the donor states in a $GaAs/Ga_{1-x}Al_xAs$ QWW of circular cross section. Several trial wave functions are used to describe the ground state of the donor impurity. Using these trial wave functions the binding energy of the donor impurity in the ground state is determined for the hydrogenic case $\epsilon(o)$, and for the non-hydrogenic case, $\epsilon(r)$.

The binding energy for the first excited state is also determined using a trial wave function which is orthogonal to the ground state trial wave function. Here again the calculation is carried out for the hydrogenic case $\epsilon(o)$, and for the non-hydrogenic case $\epsilon(r)$.

It is found that in the ground state the binding energy increases with decreasing QWW radius for both the hydrogenic ($\epsilon(o)$) and non-hydrogenic ($\epsilon(r)$) cases. However, the binding energy increases much more rapidly with QWW radius

in the non-hydrogenic than in the hydrogenic case. The spatial dielectric function leads to substantially enhanced binding energy.

For the first excited state the binding energy also increases with decreasing QWW radius but here the screening effect of $\epsilon(r)$ is negligible.

It is seen from the present work that the binding energy of a donor in a $GaAs/Ga_{1-x}Al_xAs$ increases with decreasing QWW radius and that for the ground state binding energy it is sensitive to the screening effect of $\epsilon(r)$. This is because in the first excited state the donor electron does not approach the impurity ion as closely as in the ground state.