



# **A NEW ANALYTICAL MODEL FOR A GRADED-BASE SINGLE QUANTUM WELL TRANSISTOR LASER**

By

**Mostafa Radwan Hassan Abdelhamid**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfilment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
in  
Engineering Physics

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
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Under the Supervision of

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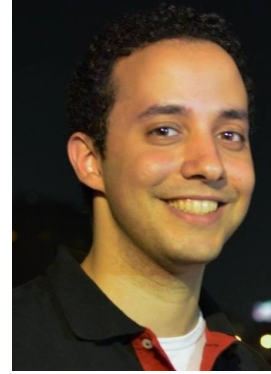
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**FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
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**Title of Thesis:**

A New Analytical Model for a Graded-Base Single Quantum  
Well Transistor Laser

**Key Words:**

Transistor Laser; Quantum-Well; Optoelectronics; modeling; composition grading

**Summary:**

The Transistor Laser (TL) device has shown great potential for the use in optical communications in the near future with its superiority in performance to the regularly used Laser Diodes (LDs). In our work, we have derived a closed-form analytical model for a Single Quantum-Well (QW) Transistor Laser (TL) device. The model incorporates the effect of thermionic-emission and tunneling at the abrupt emitter-base junction as a boundary condition for the continuity equation of the minority carriers in the base region. By combining the continuity equation with a virtual state based two-level rate equations, a complete analytical solution is obtained. The model results show good agreement with previously published experimental data. Thus, we have extended the model to investigate the effect of composition grading in the base region on the device performance. Our model shows that a lower threshold current and a higher optical bandwidth can be achieved with proper grading. A parametric study was also conducted on the proposed model to investigate the effect of different design parameters on the overall performance of the transistor laser.





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Mostafa R. Abdelhamid

*To my family and all my friends*



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