Contents

1 Introduction ................................. 1
   1.1 What is Quantum Dot? ...................... 1
   1.2 How to make Quantum Dot? ................. 3
   1.3 Motivation .................................. 4
   1.4 Importance of Nitride Based Semiconductor QDs ........... 7
   1.5 Calculation Method .......................... 12
   1.6 Problems Investigated ...................... 13
   1.7 Organization of Chapters ................... 13

2 k.p Method and a Quantum Dot .......... 16
   2.1 Introduction ................................ 17
   2.2 k.p Method .................................. 18
      2.2.1 Luttinger Kohn Functions .............. 18
      2.2.2 Scheme of k.p Method .................. 18
      2.2.3 k.p Hamiltonian ......................... 19
      2.2.4 Non-Degenerate Energy Bands ......... 21
      2.2.5 Degenerate Energy Bands ............... 22
      2.2.6 k.p Treatment of the Valence Band .... 24
   2.3 k.p Method and a Spherical Quantum Dot .... 26
      2.3.1 Eigenvalue Equation for the Wurtzite and Zinc-Blende Structures .... 29
3 Energy Levels of Nitride Quantum Dots: Wurtzite versus Zinc-blende Structure

3.1 Zinc-blende Hamiltonian Vs Wurtzite Hamiltonian
   3.1.1 Zero SOC case: Wurtzite Structure
   3.1.2 Zero SOC case: Zinc blende structure
   3.1.3 Finite SOC case

3.2 Hole Wavefunctions
   3.2.1 Wurtzite Structures
   3.2.2 Zinc-Blende Structures

3.3 Results and Discussion
   3.3.1 Zero SOC Case: Zinc-Blende Structure
   3.3.2 Zero SOC Case: Wurtzite Structures
   3.3.3 Results with SOC

3.4 Conclusions

4 Dark and Bright Excitonic States in Nitride Quantum Dots

4.1 Introduction

4.2 Selection Rules for optical transitions

4.3 Excitonic States and Dark and Bright Exciton
   4.3.1 Coulomb Attraction between Electron and Hole
   4.3.2 Inclusion of Exchange Interaction

4.4 Optical Processes at the Band Edges

4.5 Conclusions