



UvA-DARE (Digital Academic Repository)

Spectroscopic analysis of erbium-doped silicon and ytterbium-doped indium phosphide

de Maat-Gersdorf, I.

[Link to publication](#)

Citation for published version (APA):

de Maat-Gersdorf, I. (2001). Spectroscopic analysis of erbium-doped silicon and ytterbium-doped indium phosphide

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <http://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

Contents

1	Consequences of crystal-field symmetries	1
1.1	Outline of this thesis	1
1.2	Introduction to the theory	3
1.3	Many-electron wave functions, multiplets	5
1.4	Spin-orbit interaction	8
1.5	Crystal fields	11
1.5.1	T_d - Symmetric potential	11
1.5.2	Matrix elements for f functions	16
1.5.3	Perturbation Hamiltonian due to a cubic crystal field	18
1.5.4	Calculation of the matrix elements for the multiplet level ${}^4I_{15/2}$	20
	References	27
2	Photoluminescence measurements on erbium-doped silicon	29
2.1	Introduction	29
2.2	Experimental method	33
2.3	Experimental results	34
2.4	Discussion	36
2.4.1	Ligand oxygen atoms	36
2.4.2	Phonon replicas	38
2.4.3	Crystal-field analysis	41
2.5	Conclusion	43
	References	43
3	Photoluminescence of erbium-doped silicon: Improvements to the crystal-field theory	45
3.1	Introduction	45
3.2	Transformation of x and W	47
3.3	Selection rules	50
3.4	Identification of the "five" lines from among the measured ones	51
3.5	Perturbations of the ${}^4I_{15/2}$ level due to the ${}^4I_{13/2}$, ${}^4I_{11/2}$ and ${}^4I_{9/2}$ multiplet levels	53

3.6	The Tang model	56
3.7	Perturbations of the $4f^{11}: ^4I_{15/2}$ multiplet due to the $4f^{10} 6s$ levels	59
	References	61
4	Zeeman splitting factor of the Er^{3+} ion in a crystal field	63
4.1	Introduction	63
4.2	Method of calculation	66
4.2.1	Spin-orbit interaction	66
4.2.2	Crystal field	66
4.2.3	Magnetic field	67
4.3	Cubic symmetry	67
4.3.1	Energy	67
4.3.2	g Value	70
4.4	Trigonal and tetragonal symmetry	72
4.4.1	Energy	72
4.4.2	g Value	74
4.5	Orthorhombic symmetry	79
4.5.1	Energy	79
4.5.2	g Value	80
4.6	Conclusions	82
	References	84
5	Energy levels of ytterbium in indium phosphide	87
5.1	Introduction	87
5.2	Energy levels	88
5.2.1	Spin-orbit interaction	88
5.2.2	Crystal-field interaction	89
5.2.3	Transition energies	90
5.3	Energy level ordering	90
5.3.1	Photoluminescence intensity	90
5.3.2	Photoluminescence temperature dependence	93
5.3.3	Photoluminescence hydrostatic-stress dependence	94
5.3.4	Magnetic resonance	95
5.3.5	Coordination	96
5.4	Conclusions	97
	References	98

6 Zeeman studies of the 4f intrashell transitions of ytterbium in indium phosphide	99
6.1 Introduction	99
6.2 Experimental method	101
6.3 Theoretical analysis of the Zeeman splitting	101
6.4 Selection rules and consequences	106
6.5 Experimental results and discussion	109
6.5.1 State I	110
6.5.2 State II	114
6.6 Conclusion	118
References	118
Summary	119
Samenvatting	121
Populaire samenvatting	123
Dankwoord	125

