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Interaction of intrinsic defects with impurities in Al doped ZnSe single crystals

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Abstract

ABSTRACT

We report on the results of a complex study of electrical (77–300K) and luminescence (10–300K) properties of n-ZnSen-ZnSe single crystals annealed in a Zn melt containing Al impurity at concentrations ranging from 0.1 to 80 at. %. It was established that Al atoms form donor centers only at a low impurity concentration (≤0.5 at. %). The increase of the amount of Al atoms in the crystal results in the formation of (VZnAlZn) associative acceptor centers leading to the self-compensation of the shallow Al donor impurity. This process is accompanied by the emergence and development of a self-activated luminescence band associated with the (VZnAlZn) acceptor centers. We show that further increase of the Al content in the melt (≥10 at. %) leads to the dissociation of the acceptor complexes and to a recurrent donor doping effect. The photoluminescence spectra of such crystals are dominated by activated luminescence via the (CuZnVSeCui) and (CuZnAlZn) associative centers.

References

1. A. Kamata, T. Uemoto, M. Okajima, K. Hirahara, M. Kawachi, and T. Beppu, J. Cryst. Growth https://doi.org/10.1016/0022-0248(90)90731-Y 86, 285 (1990).
2. A. Yoshikawa, H. Nomura, S. Yamaga, and H. Kasai, J. Appl. Phys. https://doi.org/10.1063/1.343013 65, 1223 (1989).
3. N. Shibata, A. Ohki, and A. Katasui, J. Cryst. Growth https://doi.org/10.1016/0022-0248(88)90607-0 93, 703 (1988). 4. K. Ohkawa, T. Mitsuyu, and O. Yamazaki, J. Appl. Phys. https://doi.org/10.1063/1.339323 62, 3216 (1987).

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5. D. C. Oh, J. H. Chang, T. Takai, J. S. Song, K. Godo, Y. K. Park, K. Shindo, and T. Yao, J. Cryst. Growth https://doi.org/10.1016/S0022-0248(02)02383-7 251, 607 (2003).
6. D. C. Oh, J. S. Song, J. H. Chang, T. Takai, T. Hanada, M. W. Cho, and T. Yao, Mater. Sci. Semicond. Process. https://doi.org/10.1016/j.mssp.2003.07.017 6, 567 (2003). 7. D. C. Oh, H. Makino, T. Hanada, M. W. Cho, T. Yao, J. S. Song, J. H. Chang, and F. Lu, J. Vac. Sci. Technol. B https://doi.org/10.1116/1.1755713 22, 1475 (2004).
8. M. G. M. Choudhury, M. R. Islam, M. M. Rahman, M. O. Hakim, M. K. R. Khan, K. J. Kao, and G. R. Lai, Acta Phys. Slov. 54, 417 (2004). 9. B. Reinhold and M. Wienecke, J. Cryst. Growth 204, 434 (1999). 10. M. Prokesch, K. Irmascher, J. Gebauer, and R. Krause-Rehberg, J. Cryst. Growth 214-215, 988 (2000).
11. Y. Namikawa, S. Fujiwara, and T. Kotani, J. Cryst. Growth 229, 92 (2001).
12. T. Niina, T. Minato, and K. Yoneda, Jpn. J. Appl. Phys., Part 2 https://doi.org/10.1143/JJAP.21.L387 21, L387 (1982). 13. A. N. Georgobiani, U. A. Aminov, Yu. V. Korostelin, V. I. Kozlovsky, A. S. Nasibov, and P. V. Shapkin, J. Cryst. Growth 184-185, 470 (1998). 14. V. Z. Bolboshenko and D. D. Nedeoglo, Fiz. Tekh. Poluprovodn. (S.-Peterburg) 21, 1247 (1987)
V. Z. Bolboshenko and D. D. Nedeoglo[Sov. Phys. Semicond. 21, 755 (1987)].
15. M. Aven and H. H. Woodbury, Appl. Phys. Lett. https://doi.org/10.1063/1.1777366 1, 53 (1962).
16. Y. Shirakawa and H. Kukimoto, J. Appl. Phys. https://doi.org/10.1063/1.327919 51, 2014 (1980).
17. G. N. Ivanova, D. D. Nedeoglo, B. V. Novikov, V. G. Talalaev, Fiz. Tverd. Tela (Leningrad) 23, 2693 (1981) G. N. Ivanova, D. D. Nedeoglo, B. V. Novikov, V. G. Talalaev [Sov. Phys. Solid State 23, 1579 (1981)].
18. S. Fujita, H. Mimoto, and T. Naguchi, J. Appl. Phys. https://doi.org/10.1063/1.326084 50, 1079 (1979).
19. J. Pankove, Optical Processes in Semiconductors (Prentice-Hall, New Jersey, 1971).
20. B. V. Novikov, G. Röppisher, and V. G. Talalaev, Fiz. Tverd. Tela (Leningrad) 21, 817 (1979)
B. V. Novikov, G. Reppisher, and V. G. Talalaev [Sov. Phys. Solid State 21, 478 (1979)]. 21. R. E. Halsted and M. Aven, Phys. Rev. Lett. https://doi.org/10.1103/PhysRevLett.14.64 14, 64 (1965). 22. V. Swaminathan and L. C. Greene, Phys. Rev. B https://doi.org/10.1103/PhysRevB.14.5351 14, 5351 (1976). 23. S. Gezci and J. Woods, J. Lumin. 10, 267 (1975).
24. M. Yamaguchi and T. Shigematsu, Jpn. J. Appl. Phys. 17, 335 (1978). 25. N. Mott and W. Twoze, Adv. Phys.

https://doi.org/10.1080/00018736100101271 10, 107 (1961). 26. D. Nedeoglo, Phys. Status Solidi B 80, 369 (1977).
27. V. S. Vavilov, V. Z. Mien, G. N. Ivanova, D. D. Nedeoglo, A. V. Simashkevich, and M. V. Chukichev, Sov. Phys. Solid State 24, 3670 (1982).
28. A. J. Rosa and B. G. Streetman, J. Lumin. 16, 191 (1978). 29. R. N. Bhargava, R. J. Seymour, B. J. Fitzpatrick, and S. P. Herko, Phys. Rev. B https://doi.org/10.1103/PhysRevB.20.2407 20, 2407 (1979). 30. J. L. Merz, K. Nassau, and J. W. Shiver, Phys. Rev. B https://doi.org/10.1103/PhysRevB.8.1444 8, 1444 (1973). 31. L. Ia. Markovskii, I. A. Mironov, and Yu. S. Ryzhkin Opt. Spectrosc. 27, 167 (1969).
32. G. Stringfellow and R. H. Bube, Phys. Rev. https://doi.org/10.1103/PhysRev.171.903 171, 903 (1968). 33. V. V. Serdyuk, N. N. Korneva, and Yu. F. Vaksman, Phys. Status Solidi A https://doi.org/10.1002/pssa.2210910122 91, 173 (1985). 34. V. Z. Bolboshenko, G. N. Ivanova, I. Kolmykova, V. A. Kasiyan, D. D. Nedeoglo, and B. V. Novikov, Fiz. Tekh. Poluprovodn. (S.-Peterburg) 24, 1929 (1990).
35. M. Aven and R. H. Halsted, Phys. Rev. https://doi.org/10.1103/PhysRev.137.A228 137, A228 (1965). 36. G. Jones and J. Woods, J. Lumin. https://doi.org/10.1016/0022-2313(74)90032-5 9, 389 (1974). 37. Ph. Ged, J. Phys. Chem. Solids https://doi.org/10.1016/0022-3697(79)90059-3 40, 439 (1979).
38. S. Tida, J. Phys. Soc. Jpn. https://doi.org/10.1143/JPSJ.25.177 25, 177 (1968). 39. S. Shionoya, J. Phys. Soc. Jpn. 19, 1157 (1950).
40. P. L. Kukk and O. Palmre, Izv. Akad. Nauk SSSR, Neorg. Mater. 16, 1916 (1980).