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材料合成及性能

不同生长条件下ZnO薄膜电学性质的研究

赵鹏程[1,2], 张振中[1], 姚斌[3], 李炳辉[1], 王双鹏[1], 姜明明[1], 赵东旭[1], 单崇新[1], 刘雷[1], 申德振[1]
1. 发光学及应用国家重点实验室 中国科学院长春光学精密机械与物理研究所, 吉林 长春 130033;
2. 中国科学院大学, 北京 100049;
3. 吉林大学 物理学院, 吉林 长春 130023

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摘要： ZnO薄膜中的高的背景电子浓度能够对p型掺杂形成补偿,从而对p型掺杂造成障碍,了解高背景电子浓度的来源有助于对p型掺杂的研究。本文采用分子束外延技术在不同真空度下在a面蓝宝石衬底上生长了一系列氧化锌薄膜,发现在低真空度下生长的样品的载流子浓度较高,为10^{19} cm^{-3}量级;而高真空度下生长的样品,其载流子浓度比低真空生长的样品显著降低,降低了3个数量级。在相同条件下生长的样品,通过不同的后处理手段进行处理后,其电子浓度未发生明显变化,说明氧空位等本征缺陷不是ZnO薄膜中电子的主要来源,高背景电子浓度应该与生长过程中非故意引入的杂质相关。通过低温光致发光表征,发现低真空度下生长的样品在低温下3.366 eV处有强的施主束缚激子发光峰,而高真空度下生长的样品的此发光峰显著变弱。由此,高电子浓度被归结为与生长过程中非故意引入的氢杂质相关。

关键词： ZnO 高背景电子浓度 生长室真空 氢杂质

Electrical Properties of ZnO Thin Films Growth Under Different Conditions

ZHAO Peng-cheng[1,2], ZHANG Zhen-zhong[1], YAO Bin[3], LI Bing-hui[1], WANG Shuang-peng[1], JIANG Ming-ming[1], ZHAO Dong-xu[1], SHAN Chong-xin[1], LIU Lei[1], SHEN De-zhen[1]
1. State Key Laboratory of Luminescence and Applications, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033, China;
2. University of Chinese Academy of Sciences, Bejing 100049, China;
3. Department of Physics, Jilin University, Changchun 130023, China

Abstract: The high background electron concentration in ZnO films can compensate the forming of acceptor, which causes difficulties for p-type doping. Understanding the source of the high background electron concentration is helpful to realize high-efficient p-type doping. In this paper, a series of ZnO thin films were grown on *a*-plane sapphire substrates under different vacuum by molecular beam epitaxy. The samples grown under low vacuum show high carrier concentration of about 10^{19} cm^{-3}, however, the electron concentration of the samples grown under high vacuum is significantly lower than the samples grown under high vacuum by three orders of magnitude. For the samples grown under low vacuum, the electron density did almost not change after annealing with various post-treatment, indicating the intrinsic defects, such as oxygen vacancy, are not the main source of electrons in ZnO films. The high background electron concentration should originated from the impurities unintentionally introduced during the growth. The samples grown under low vacuum showed a strong photoluminescence peak at 3.366 eV at 85 K, which is related to shallow-donor-bound exciton. For the samples grown under high vacuum, this emission was weakened markedly. Therefore, defects related to hydrogen were assigned to the main source of the high electron concentrations in the case of low vacuum growth.

Keywords: ZnO high electron concentration chamber vacuum hydrogen

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通讯作者: 张振中

作者简介: 赵鹏程(1984-), 男, 内蒙古包头人, 主要从事ZnO薄膜外延生长及p型掺杂研究。 E-mail: pchzhao@163.com, Tel: (0431)86176322

作者Email: exciton@163.com

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