



材料合成及性能

纤锌矿 $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ 抛物量子阱中极化子能级

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摘要：采用改进的Lee-Low-Pines(LLP)中间耦合方法研究纤锌矿 $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ 抛物量子阱材料中的极化子能级, 给出极化子基态能量、跃迁能量(第一激发态到基态)和不同支长波光声子对电子态能级的贡献随量子阱宽度 d 的变化规律。理论计算中考虑了纤锌矿 $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ 抛物量子阱材料中声子模的各向异性和介电常数、声子(类LO和类TO)频率等随空间坐标 Z 变化(SD)效应对极化子能量的影响。结果表明, $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ 抛物量子阱中电子与长波光声子相互作用对极化子能级的移动很大, 使得极化子能量明显降低。阱宽较小时, 半空间长波光声子对极化子能量的贡献较大, 而定域长波光声子的贡献较小; 阱宽较大时, 情况则正好相反。在 d 的变化范围内, 电子与长波光声子相互作用对极化子能级的移动(约67~79 meV) 比 $Al_xGa_{1-x}As/Al_{0.3}Ga_{0.7}N$ 抛物量子阱中的相应值(约1.8~3.2 meV) 大得多。因此, 讨论ZnO基量子阱中电子态问题时要考虑电子与长波光声子的相互作用。

关键词：抛物量子阱 电子-光学声子相互作用 极化子

Polaron Energy Level in Wurtzite $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ Parabolic Quantum Well

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Abstract: The energy levels of polaron in a wurtzite $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ parabolic quantum well are investigated by adopting a modified Lee-Low-Pines variational method. The ground state energy, the transition energy and the contributions of different branches of optical phonon modes to the ground state energy as functions of the well width d are given. The effects of the anisotropy of optical phonon modes (like-LO and like-TO) and the spatial dependence effective mass, dielectric constant, phonon frequency on energy levels are considered in theoretical calculation. The results indicate that the contributions of the electron-optical phonon interaction to polaron energy shift in $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ parabolic quantum well are very large, which make the energy of polaron reduce. For a narrower quantum well, the contributions of half-space optical phonon modes is large, and the contributions of the confined optical phonon modes is small, while for a wider one, the case is contrary. In the region of d , the contributions of the electron-optical phonon interaction to polaron energy shift in wurtzite $Mg_xZn_{1-x}O/Mg_{0.3}Zn_{0.7}O$ (about from 67 to 79 meV) are greater than that of $Al_xGa_{1-x}As/Al_{0.3}Ga_{0.7}N$ parabolic quantum well (about from 1.8 to 3.2 meV). Therefore, the electron-optical phonon interaction should be considered in studying electron state in ZnO based quantum well.

Keywords: parabolic quantum well electron-optical phonon interaction polaron

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