Origin of Point Defects in AgInS$_2$ Epilayer
 Obtained From Photoluminescence
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Abstract: The AgInS$_2$ epilayers with chalcopyrite structure grown by using a hot-wall epitaxy (HWE) method have been confirmed to be a high quality crystal. After the as-grown AgInS$_2$/GaAs was annealed in Ag-, S-, and In-atmosphere, the origin of point defects of the AgInS$_2$/GaAs has been investigated by using the photoluminescence (PL) at 10 K. The native defects of V$_{Ag}$, V$_S$, A$_{Bun}$, and S$_{ext}$ obtained from PL measurement were classified to donors or acceptors type.

Key Words: AgInS$_2$, hot-wall epitaxy, point defects, Varshni's relation, photoluminescence

1. Introduction

Ternary chalcopyrite crystals are currently of technological interest since they show promise for application in the areas of visible and infrared light-emitting diodes, infrared detectors, optical parametric oscillators, upconverters, and far infrared generator. In this paper, to estimate the predominant point defects of the as-grown AgInS$_2$ through various heat-treatment, we carried out measurements of the optical absorption and the PL spectra. Based on these results, we will discuss the origin of native defects of the AgInS$_2$.

2. Results and Discussion

The absorption and PL spectra of AgInS$_2$/GaAs epilayers grown by using HWE method were investigated. The energy band gap obtained from the absorption spectra was well described by the Varshni's relation of $E_g(T) = 2.1365$ eV - $(9.89 \times 10^3$ eV$)^2/(2930 + T)$. The free excitons of the lhx and hhx have found in the as-grown AgInS$_2$/GaAs and its splitting energy gap between the lhx and the hhx was determined to be 109 meV. Also, the binding energy of the free exciton was estimated to be 48.2 meV. The I$_3$ emission was confirmed to be related to the V$_S$ or A$_{Bun}$ generated by non-stoichiometric composition. These defects were proved to be acted as donors. Therefore, these defects indicate one of the reasons why the AgInS$_2$ grown is generally the n-type. At the same time, the binding energy of the donor-impurity was calculated to be 92.7 meV. The I$_1$ emission became the dominant peak in the AgInS$_2$/GaAs:S after the S-atmosphere treatment.

References


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