2023年第70回応用物理学会春季学術講演会 講演予稿集 (2023 上智大学　四谷キャンパス+オンライン)

MOVPE 法により微斜面基板上に成長させた p 型 C ドープ AlGaAs の低温フォトルミネッセンス測定

Low-temperature photoluminescence investigation of p-type C-doped AlGaAs grown by MOVPE on vicinal substrates

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III-V compound multi-junction solar cells (MJSC) are widely used in the aerospace field and Concentration photovoltaics (CPV) because of their superior stability and ultrahigh photoelectric conversion performance. The state-of-the-art MJSC achieved a monolithic six-junction structure with a world record power conversion efficiency of 47.1% [1]. However, the extended junction number also puts forward higher requirements for adjusting the bandgap of current materials to meet the optimal bandgap combination.

AlGaAs stands out as a promising material for top subcell(s) due to its wide tunable bandgap from 1.42 eV to 2.16 eV with its lattice-matched growth on GaAs substrate. However, we still lack the knowledge to obtain defect-free AlGaAs with excellent radiative efficiency that pushes performance to the limit. One common method to improve epitaxial crystal quality, which has been studied in other III-V compounds, is to use vicinal substrates for crystal growth (i.e., substrates with a slight misorientation from (0 0 1)) [2,3].

This paper studies AlGaAs double heterostructure (DH) samples grown on four types of GaAs substrates regarding their low-temperature photoluminescence (PL) results to analyze the dependencies of substrate orientations. Mutual comparison of the temperature dependence of PL intensity (Fig. 1) among samples gives us insight into how non-radiative recombination is enhanced in the temperature range above 20 K ($1/T < 0.05$). The quenching rate increases as the miscut angle increases, indicating the degraded crystal quality of AlGaAs with strong non-radiative recombination when grown on vicinal substrates. This observation was later validated by comparison of two solar cell devices grown on 2°-off and 5°-off substrates, respectively.

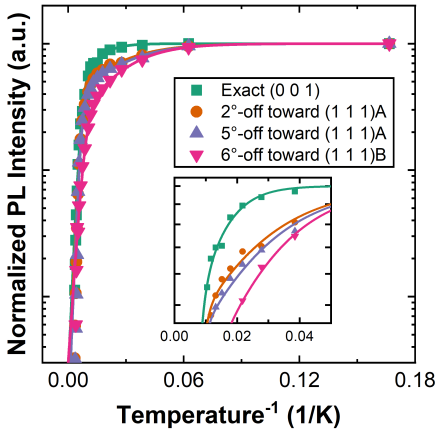

Fig. 1. Arrhenius plot of PL intensities of AlGaAs DH samples on various substrates. Inset: zoom-in of different quenching rates at the temperature range above 20 K

Reference:

1) J. F. Geisz *et al.*, *Nat. Energy* **5** [4], 326 (2020)
2) M. Suzuki, Dr. Thesis, Waseda University, Tokyo (2007).
3) S. Park *et al.*, *Solar Energy* **220**, 406 (2021)