18a-A28-7

InGaP/GaAs/Ge 3 接合太陽電池のサブセルの内部発光量子収率評価とエネルギー変換効率への影響

Analysis of Internal-luminescence-quantum-yield of Subcells in InGaP/GaAs/Ge triple-junction solar cells and their influence on energy conversion efficiencies

○朱琳 [1]，陳少強 [1]，吉田正裕 [1]，望月敏光 [1]，金昌秀 [1]，秋山英文 [1]，今泉充 [2]，金光義彦 [3]

ISSP, Univ. of Tokyo[1], JAXA[2], ICR, Kyoto Univ.[3]

E-mail: zhulin@issp.u-tokyo.ac.jp

The ideal conversion efficiency limit of multi-junction (MJ) tandem solar cell (η_{sc}) had been theoretically formulated as an efficiency reference via detailed balance principle [1]. In order to provide a reliable reference for the realistic design, in our previous works, we had theoretically analyzed the dependence of η_{sc} and the optimized sub-cell band-gap energies on the geometric mean (y_{int}^{*}) of the individual sub-cell internal luminescence quantum yield (y_{int}), which characterizes material quality of each sub-cell in a tandem structure [2]. Recently, we have developed a useful method for diagnosing MJ tandem solar cells based on the measurements of the absolute electroluminescence (EL) quantum yields (y_{ext}^{LED}) of individual sub-cells and the evaluation of the external luminescence yields (y_{ext}) [3, 4].

In this work, we extend our analysis method and quantify y_{int} from the measured y_{ext} to investigate the influence of material quality of each sub-cell on η_{sc} . Fig. 1(a) shows quantified y_{int} of three sub-cells and their y_{int}^{*} of a space InGaP/GaAs/Ge 3-junction tandem solar cell as a function of the injection current in LED (J^{LED}) and solar-cells (J^{SC}) operations, which are strongly dependent on the current density. The y_{int} of top-, middle-, bottom-cells and y_{int}^{*} at $J^{SC}= J_m$ (maximum-power condition) are 1.4, 5.6, 0.3, and 1.2%, respectively, while those at $J^{SC}= 0$ (open-circuit condition) are 4.9, 55.9, 3.2, and 4.4%, respectively. We also evaluated η_{sc} from the quantified y_{int}^{*} at J_m (the pink cross) and compare it with the theoretical estimation of η_{sc} for two typical y_{int}^{*} cases, shown as Fig. 1 (b), showing a good agreement with conclusions of our previous work [2]. The maximum η_{sc} of 28.7% was obtained at y_{int}^{*}=1.2% and J_m =-16.6 mA/cm^2, which is close to the experimental η_{sc} of 27.4%. It reveals that this experimental method to quantify each sub-cell y_{int} is feasible and reliable.

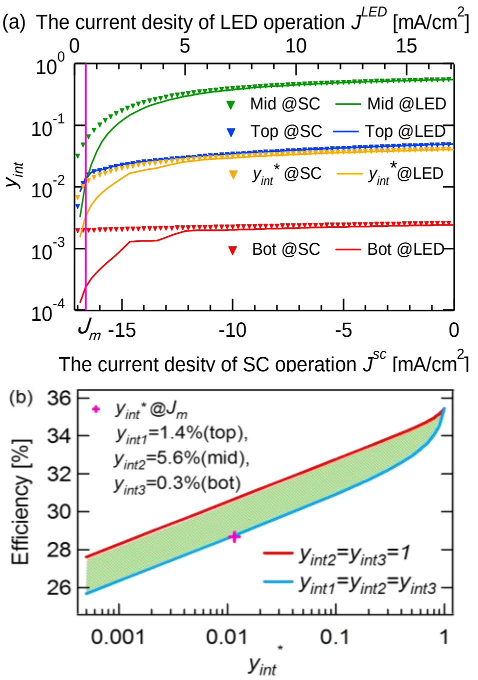

Fig. 1 (a) Quantifed y_{int} as a function of the injection current in LED and SC operations. (b) η_{sc} as functions of y_{int}^{*}

[1] A. D. Vos, J. Phys. D: Appl. Phys.13, 839 (1980). [2] L. Zhu et al., 40th IEEE PVSC Proceedings, Denver, USA, 2014. [3] S. Chen et al., 40th IEEE PVSC Proceedings, Denver, USA, 2014. [4] M. Yoshita et al., this JSAP 2014 fall Meeting.