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トンネル援用 InGaAs/GaAsP 量子井戸セルにおけるキャリア脱出のバイアス依存性

Investigation of the bias-dependent carrier escape for InGaAs/GaAsP tunneling-assisted structure solar cell

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We induced a novel resonant thermo-tunneling design for the InGaAs/GaAsP MQWs system to facilitate the photon-generated carriers' escape [1]. A thin well was placed next to the main absorber thick well with a thin barrier between them, and through optimizing the confinement energy levels and barrier thicknesses, a sequential thermionic promotion and tunneling process could be achieved with an overall faster escape time. We have successfully fabricated the designed tunneling-assisted MQWs structure and proved the enhancement of external quantum efficiency (EQE) at the long wavelength compared with conventional thick well MQWs. In this work, we have investigated the bias dependence of tunneling-assisted structure solar cell in the aspects of carrier decay time and EQE.

We have fabricated solar cells with tunneling-assisted structure and thick well MQWs which share the same total thickness of well layers. The bias dependent performance of these two solar cells has been investigated. As shown in Fig. 1 (a), the bias-dependent carrier decay time has been extracted from the time-resolved photoluminescence (TRPL). It is clear that the carrier decay time of tunneling-assisted structure is faster than that of thick well MQWs at the reverse bias or small forward bias, which indicates the quicker carrier escape. But with the increase in forward bias, the carrier decay time of tunneling-assisted structure becomes comparable with that of thick well MQWs. The same phenomenon has been observed for the bias dependent EQE at the wavelength of 1030 nm, which is the absorption by the thick wells, as illustrated in Fig. 1 (b). The reason for these phenomena would be that the reverse bias enhances the tunneling effect and carriers' escape are accelerated by the tunneling-assisted process, while the large forward bias obstacles the tunneling effect and breaks the tunneling-assisted escape process.

[1] S. Ma et al., Proceeding of IEEE 38th PVSC, Austin, TX, USA (2012).

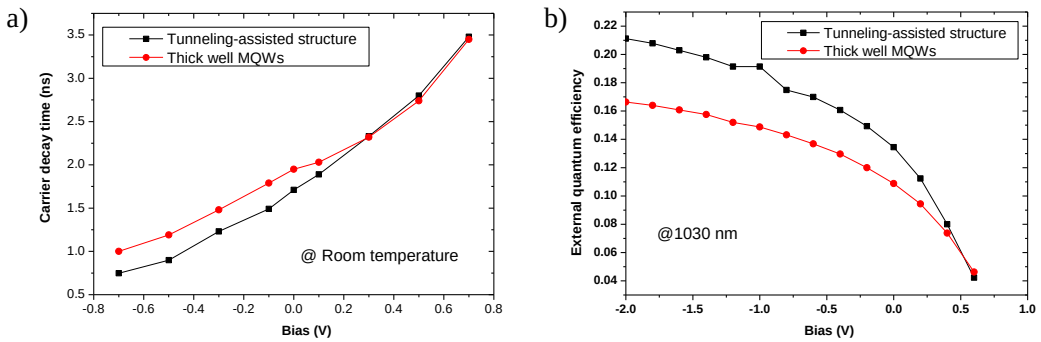

Fig. 1. (a) Carrier decay time extracted from TRPL and (b) EQE vs. bias voltage for tunneling-assisted structure (black line) and thick well MQWs (red line).