Novel Structural Designs for Engineering Terahertz Emitting Resonant Tunnelling Diodes

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Resonant tunnelling diodes (RTDs) find application in terahertz wave electronics and photonics including spectroscopic sensing, imaging, and ultra-broadband wireless communications [1]. The RTD is a compact, coherent, room temperature THz device that lends itself to integration with other functional electron/optical devices [2]. Such epitaxial structures are difficult to characterise using non-destructive techniques.

An analysis of high resolution X-ray diffractometry (HRXRD) as a function of structural variations is made to indicate sensitivity and accuracy limits for determining the structure via XRD alone. The summary of this is shown in Fig 1. Difficulties in making this analysis are reduced by linking growth rates of identical layers in metal-organic vapour phase epitaxy (MOVPE). This notwithstanding, we deduce that the resulting uncertainty in structure translates to an uncertainty of ±40meV in the energy of the 1st confined energy state with respect to the emitter Fermi level (ΔE). Furthermore, this uncertainty does not consider uncertainties in band-offsets.

Low temperature photoluminescence spectroscopy (LTPL) is a powerful technique [3], but does not provide a unique solution for the Type-I LTPL transition. We show that LTPL of doped *and* undoped QWs allows finding ΔE without band-offset uncertainty. We show the effect of a buried "dummy" active region beneath the device, adding a Type-II transition in the PL spectra, with negligible impact on the XRD rocking curve. We discuss the sensitivities of these transitions to the device structure. Using the HRXRD results as a base, and including LTPL using an additional "dummy" QW, ΔE can be determined to ±2meV. Along with determining the wafer doping distribution via the Moss-Burstein shift, improved structural info can also be inferred, aiding the epitaxial process.

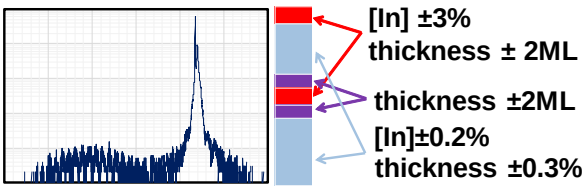

Fig. 1. Schematic layer structure stack of the AlAs/InGaAs/InP RTD and degree of HRXRD-only fit accuracy

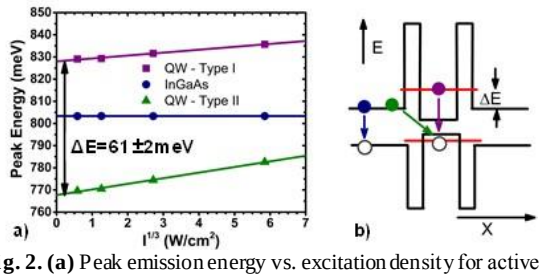

Fig. 2. (a) Peak emission energy vs. excitation density for active and 'dummy' RTD QW. **(b)** Band-structure showing the possible luminescence transitions.

References

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