Assessing MBE regrowth quality on transfer printed virtual substrates

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III-V semiconductor devices provide the highest performance in many optoelectronic applications, including solar cells. However, the large cost to produce these devices can make them very expensive compared to lower quality counterparts. One key factor driving the cost of III-V devices is the high cost of high quality, single crystalline substrates. To address this issue, we have been developing a new technique which we call transfer printed virtual substrates (TPVS). In this technique, shown in Figure 1, a large number of virtual substrate layers, separated by epitaxial release layers, are grown on a source substrate. From this source substrate, virtual substrate layers are moved to separate low cost handles using micro-transfer printing. By iterating through many layers of the source substrate stack, one source substrate can be used to produce a large number of low-cost, epi-ready virtual substrates, which can in turn be used to produce a variety of microscale devices.

In this presentation, we will illustrate the quality of epilayers grown on TPVS by MBE [1,2]. To evaluate surface morphology and optical quality we grew a GaAs/AlGaAs MQW structure on a GaAs TPVS and control wafer. We observed similar surface roughness, XRD peak width and PL linewidths on both the TPVS and the control samples. We've also produced a device demonstration using identical GaAs solar cell structures grown on a native substrate and a TPVS. The efficiency of devices grown on a TPVS is degraded by less than 2% absolute efficiency from the control structures (Figure 2), both under one-sun conditions and under concentration. The experiments suggest that with further process enhancement, TPVS should be able to produce identical performance devices with much lower cost.

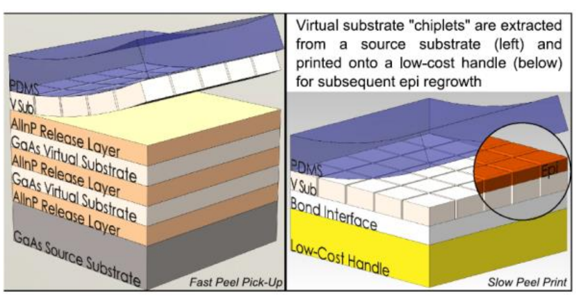

Figure 1: Schematic describing the TPVS concept.

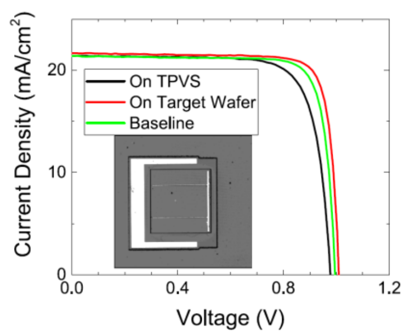

Figure 2: AM1.5G 1-sun light-IV results of GaAs solar cells in this study.

[1] K.J. Schmieder, M.P. Lumb, M.F. Bennett, C.R. Haughn, S. Mack, M.K. Yakes, S.I. Maximenko, R.J Walters, Jour. Crys. Growth **507**, 402 (2019).

[2] K.J. Schmieder , M.P. Lumb, M.F. Bennett, S. Tomasulo, M.K. Yakes, S. Mack , J.E. Moore, and R.J. Walters, IEEE Jour. Photovoltaics **6**, 1641 (2018).

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