

Controlling growth rate and band-gap by combining *in situ* measurements and reflectance model for molecular beam epitaxy fabrication

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Abstract and open questions:

The *in situ* and real-time measurement of the semiconductor materials growth rates and bandgaps is a key element to better control the epitaxy of high efficiency solar cells, and more generally complex multilayer semiconductor structures. However, no universal practical tool has been implemented today¹⁻³, and in particular in any growth conditions and for any materials.

In my thesis, I'm working on a methodology to extract growth rates, band-gap and optical constants from measured *in situ* reflectance of a growing thin film by molecular beam epitaxy (MBE). The reflectance is measured over a wide spectral bandwidth (320 - 1700 nm) enabling to measure a wide range of material with different optical properties, such as AlGaAs alloys or 1eV InGaAsN.

The method uses virtual interface reflectance model to fit measured spectral reflectivity of over the time. From which we can deduce the overall growth rate of the growing layer.

This model can be improved by combining it with *in-situ* measurements of band-edge thermometry⁴ and magnification inferred curvature⁵, in order to extract the absolute substrate temperature and alloy composition, respectively. One of the objectives is to improve the fidelity of the optical model at growth temperature, allowing to better deconvolute each cell's growth rate contribution. The long-term objective is to be able to recalibrate in real time each group-III cells to match the targeted layer thickness.

As a first trial to implement this method, we will apply it for the growth of GaAs/AlGaAs solar cell. In order to confirm the method accuracy, the same parameters will be counter-measured with *ex-situ* high resolution X-ray diffraction measurements and scanning electron microscopy.

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