SiNx Staircase Fabry-Pérot Interferometry Optical Index Measurements of InAs/$Al_{0.2}$GaAs Quantum Dots for Intermediate Band Solar Cells

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Quantum Dots (QDs) absorbers have recently been investigated for their potential application in Intermediate Band Solar Cells (IBSCs) to overcome the SQ limit. InAs/AlGaAs system, with the larger gap of the barrier material, offers new possibilities to overcome some of the problems encountered in InAs/GaAs and opens the path for QDs-IBSCs capable of achieving high efficiency at room temperature. Nevertheless the InAs/AlGaAs system is still not well-known and requires more investigations especially if we wish to combine it with light management techniques that requires accurate knowledge of the complex optical index $\tilde{n}$ ($\tilde{n} = n + i\,\kappa$).

The refractive index of bulk materials or thin films is generally determined by ellipsometry. However, a few studies have shown that $\tilde{n}$ can also be obtained using Fabry-Perot (FP) interferometry. At normal incidence, this technique is particularly suitable for anisotropic materials, such as QDs, as it provides the optical index in the plane of the QDs layers. Transmission measurements can also be performed, but thick epitaxial layers (several microns) are required, which is very difficult for QDs materials because of strain accumulation and inhomogeneity of QDs layers.

In our study, we performed reflectivity measurements as shown in figure 1 using Fourier-transform infrared spectrometry on a SiNx staircase patterned sample described in figure 2. The sample consist of 20 layers of InAs/$Al_{0.2}$GaAs QDs layers grown by molecular beam epitaxy, total thickness is 550 nm. FP resonances have a quality factor of about 10, which enables an enhanced absorption. The tuning of the SiNx thickness on the front side enable to shift the FP resonance to sweep the spectral range of interest in the characterization of optical index. This technique is important to confront absorption value compared with level of absorption calculated using k.p simulation and thus see the potential application of light trapping.

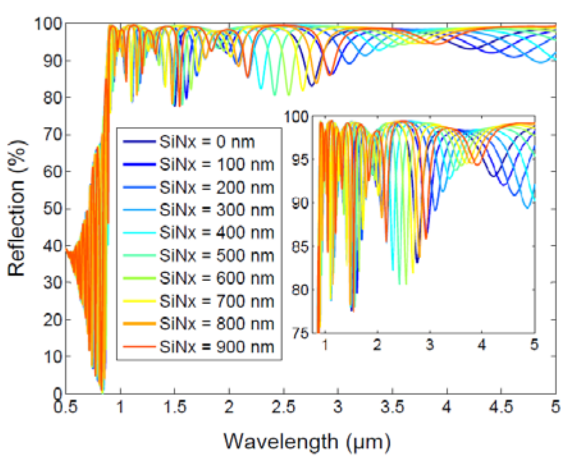

Fig 1. FP interferometry reflectivity simulation

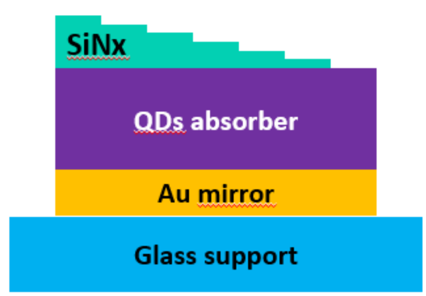

Fig 2. SiNx staircase pattern on QDs absorber