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Toward The Establishment of Reference Samples for The Calibration of Dopant Concentrations in Vertically Aligned Nanowires

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THE incorporation of vertically aligned arrays of semiconducting nanowires has been recently attracting much attention for its potential effect in increasing solar cells' efficiency. However, the photovoltaic properties of the final device is merely representative of the collective response of all nanowires in the implemented arrays. Manufacturing imperfections and integration processes are very likely to induce uncontrollable failures to individual nanowires, which in turn affects the final device's performance. Linking the device's properties to the mapping of the individual nanowires properties offer a highly desirable path toward the understanding and control of the collective behavior on the elementary scale. Owing to size confinement effects, the semiconducting properties on individual nanowires (e.g., dopant concentrations) are prone to a multitude of influencing factors, which raises significant challenges for conclusive characterizations, especially when comparing different fabrication methods.

In this communication, we propose the development of multilayers-based GaAs samples as a reference system for the calibration of dopant concentrations adapted for a further measurement on individual GaAs nanowires. Scanning microwave microscopy (SMM), is a flagship method for the measurement of impedances at the nanoscale using a sharp and conductive atomic force microscopy (AFM) probe coupled to a microwave (RF) source and a vector network analyzer (VNA). SMM exploits the electromagnetic response of materials within a broadband range up to 20 GHz in our case.

We use SMM to measure the impedance of doped GaAs multilayers with a thin layer of native oxide. This configuration enables the determination of their dopant concentrations typically ranging between 5×10^{16} cm^{-3} and 2×10^{19} cm^{-3}. Moreover, secondary-ion mass spectrometry (SIMS) is used to characterize the same set of multilayer samples. The uncertainties on SIMS measurements have been largely investigated in the literature providing concentration values within an overall 10 % uncertainty and concentration ratios with a typical uncertainty of 1 %.

To investigate the uncertainty on our SMM measurements, relative variations between the dopant concentrations of the different layers measured by SMM and SIMS we compared and found in good agreement within ± 10 %. A same level of agreement is obtained for doping concentration ratios measured on two multilayer samples placed side by side under the SMM probe.

With this level of uncertainty on the dopant concentrations for our developed GaAs multilayers samples, we propose their use as reference samples for further calibrated measurements of dopant concentrations on axial and radial *pn* junction Nanowires. This constitutes a first step toward the calibration of dopant concentrations on vertical semiconducting nanowires with a 10 % uncertainty. Further investigations are in progress and first results on doping concentrations measured by SMM on the top surface of vertically aligned nanowires will be presented at the time of the conference.

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References

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