Local electromagnetic field enhancement on Si/InAs axially heterostructured NWs

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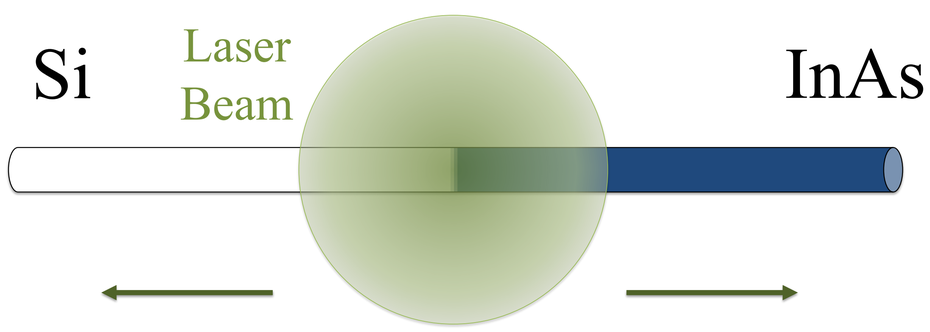
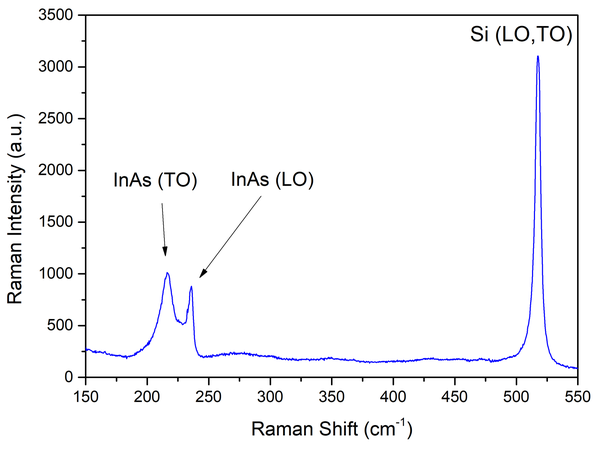
Introduction

Local electromagnetic (EM) field enhancement at the heterojunction (HJ) of axially heterostructured Si/SiGe NWs has been studied in previous works. A similar effect is predicted to appear in Si/InAs NWs and it has been detected both experimentally, by Raman Spectroscopy, and theoretically reproduced by finite element methods (FEM) simulations.

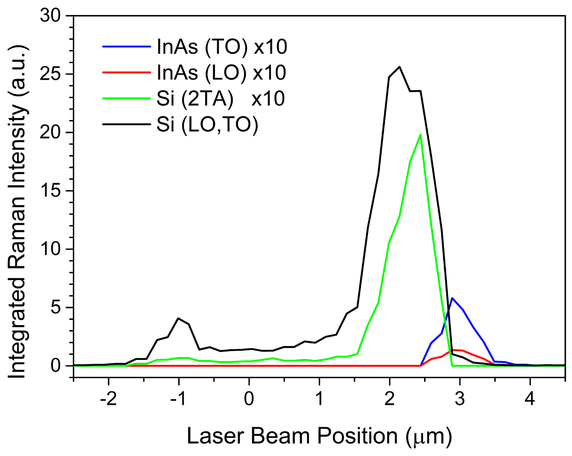
Experimental



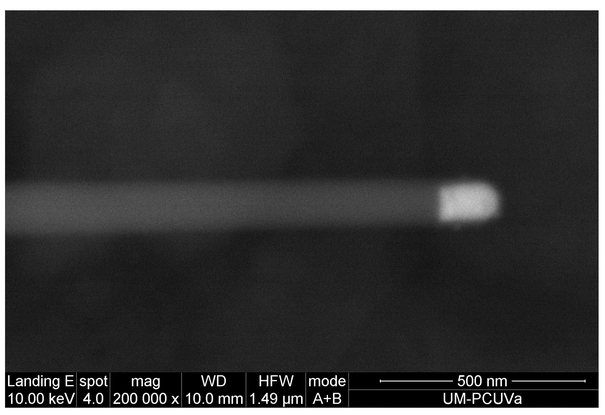
Raman spectra along the NW are acquired by scanning the laser beam in steps of 100 nm.



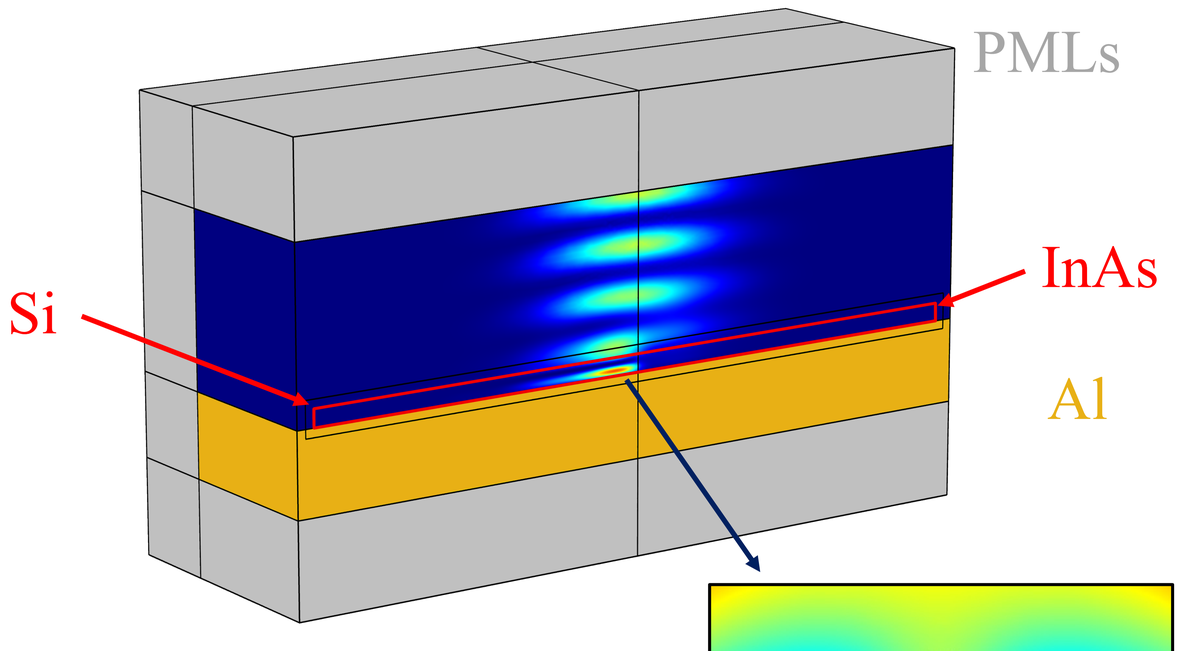
Typical Raman spectrum when the Si/InAs HJ is being illuminated, both Si and InAs Raman signal can be detected at the same time.



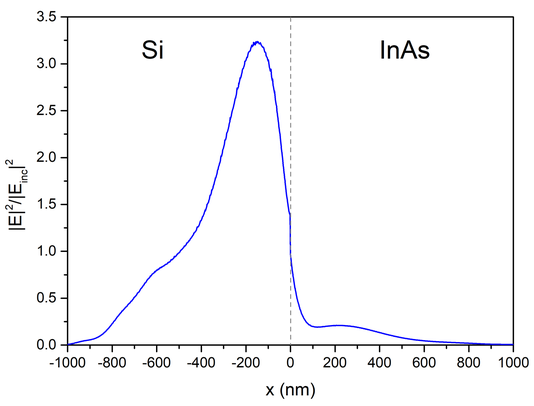
Recorded Raman intensities along the NW axis. This Raman profile shows how the Raman intensity varies along the NW axis and evidences the presence of the Si/InAs HJ with a clear enhancement of all Raman signals in its vicinity. The Si Raman signal is enhanced up to 25 times near the HJ with respect to the Si signal recorded at the homogeneous segment. Note that InAs and Si are polar and non-polar, respectively, which makes them immiscible giving an abrupt HJ.



Simulations



The FEM simulations were done on a heterostructured Si/InAs NW with an analogous structure to that of the measured NWs. It is placed on an Al substrate and surrounded by air to reproduce the experimental measurements. All the system is surrounded by Cartesian perfectly matched layers (PMLs) which absorb all the outgoing radiation. The NW is illuminated by a linearly polarized Gaussian laser beam with 532 nm wavelength. This FEM model allows to calculate the electromagnetic field distribution inside the NW, and by integrating $|E|^2$ the theoretical Raman profile along the NW can be calculated.



The EM field distribution inside the NW shows a high localization on the Si side right next to the HJ, which is in perfect agreement with the experimental measurements. The simulations also show a lower enhancement of the EM field in the InAs side, due to its higher dielectric losses. $k_{Si} = 0.03325$, $k_{InAs} = 1.0831$

Conclusions

The EM amplification already detected in Si/SiGe axially heterostructured NWs has been detected in Si/InAs NWs. The amplification is clearly visible in the longitudinal Raman profiles and de FEM model reproduces the experimental measurements, suggesting the potential use of axial heterostructures for photovoltaics and photon detection.

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