Three-dimensional Mapping of Isotopes in Semiconductor Nanowires

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Nanowires offer a playground for new material science and new physics [1,2]. Their unique geometry enables on the one hand new material growth opportunities like the hetero-epitaxy of mismatched materials [3], crystal phase engineering [4,5], and the design of specific topologies [6,7] and on the other hand the exploration of low dimensional physics like quasi one-dimensional carrier [8,9] and phonon transport [10,11].

These properties make nanowires an interesting testbed for isotope engineering, making it possible to investigate the influence of isotopes, hence the spin and mass of the nuclei on phonon- and charge transport [10-13] and the interaction of the material with electromagnetic radiation [14].

Mapping the distribution of isotopes in a nanowire in order to develop appropriate material growth protocols is unfortunately challenging as their small size and unique geometry make the application of SIMS – the standard technique to track isotopes in materials [15] – impractical. Furthermore, electron and X-Ray based microscopy that can readily be applied to nanowires [4,5,16] is not sensitive to isotopes.

Here we show that Atom Probe Tomography (APT) can be used to map the distribution of isotopes in nanowires. First, we use measurements of SIMS and APT on bulk materials and layers to establish that APT quantifies isotopic concentrations correctly down to the ppm level. Second, we apply APT to nanowires and show that we can quantify isotopes at the same sensitivity as well as map their positions along both the long axis and the cross-section of the nanowires.

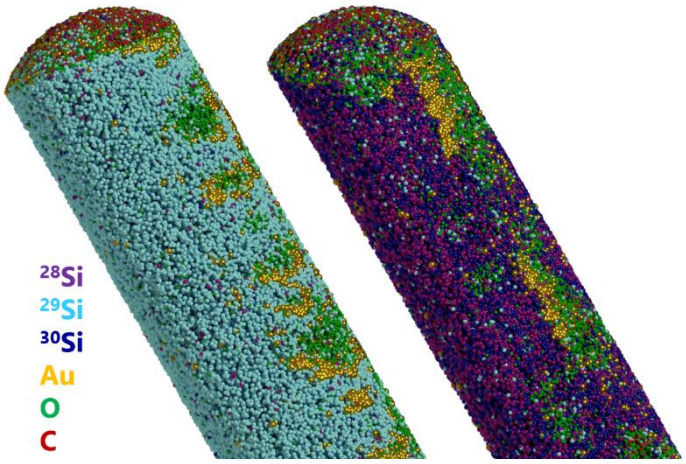

Fig.1. *APT measurements of isotope engineered Silicon nanowires grown from ^{29}Si(left) and a mixture of ^{28}Si/^{30}Si (right). This makes it possible to engineer the same material with the same effective mass but different levels of disorder [17].*

References

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