In-situ Raman measurement of an individual Silicon nanowire trapped using optoelectronic tweezers (OET)

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Abstract: We demonstrate in-situ Raman measurements of individual silicon nanowires (100 nm diameter, 10-20 μm in length) which are trapped using optoelectronic tweezers (OET).
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Optoelectronic tweezers (OET) is a dynamic, non-invasive optical manipulation tool that works based on the principle of light-induced dielectrophoretic force. It is capable of trapping many different types of particles including polystyrene beads, cells, and semiconducting nanowires [1,2]. In this work, we demonstrate the in-situ Raman measurement of an individual silicon nanowire that is trapped using optoelectronic tweezers.

In-situ Raman spectroscopy has been used by other manipulation methods such as optical tweezers to study biological cells, micro and nanostructures [3,4]. However, OET's low required optical power density, large working area, and ability to massively manipulate cells in liquid buffer makes it highly biocompatible [1]. Therefore, OET-trapped nanostructures can be used for future non-invasive probing and imaging applications. In addition, in-situ Raman measurements of OET-trapped individual nanowires will be useful for sorting and separating nanowires of different compositions, sizes, surface functionalities, as well as for creating arrays of single nanowires of alternating properties.

Fig. 1a shows the experimental setup for Raman measurements of trapped silicon nanowires. The liquid buffer containing the silicon nanowires (100 nm diameter, 10-20 μm in length) was introduced into the OET device. At first, no voltage was applied to the device and the nanowires were undergoing Brownian motion. Once the voltage was applied to the device, a single silicon nanowire was attracted to the laser spot. Upon trapping of the individual silicon nanowire, the silicon Raman peak was observed in the Raman spectra (fig. 1b). The Raman peak, approximately 520 cm^{-1}, agrees with typical reported values for large silicon nanowires [5].

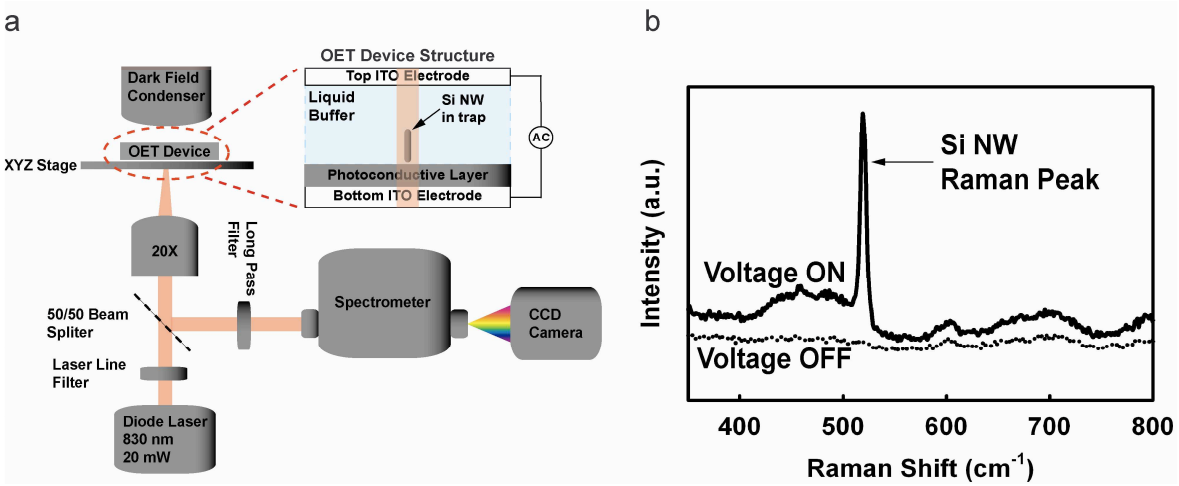

Fig. 1: (a) Experimental setup for Raman measurement of an individual silicon nanowire: a diode laser (830 nm , 20 mW optical power) is focused onto the OET surface using a 20X objective. An AC voltage of 15 Vpp at 100 KHz is applied across the device. The Raman signal is collected using a spectrometer and a CCD camera. (b) No Raman signal was detected in the absence of an AC voltage (dotted line). Once the voltage was applied, an individual silicon nanowire was attracted to the laser and the silicon Raman peak was detected (solid line).

References

[1] P.Y. Chiou, et al, "Massively parallel manipulation of single cells and microparticles using optical images", Nature, Vol. 436, 2005.
[2] A. Jamshidi, et al, "Semiconductor nanowire manipulation using optoelectronic tweezers", IEEE International Conference on MEMS, 2007.
[3] K. Ajito, et al, "Single nanoparticle trapping using a Raman tweezers microscope", Applied Spectroscopy, Vol. 56, No. 4, 2002.
[4] C. Xie, et al, "Near-infrared Raman spectroscopy of single optically trapped biological cells", Optics Letters, Vol. 27, No. 4, Feb. 2002.
[5] B. Li, et al, "Raman spectral study of silicon nanowires", Physical Review B, Vol. 59, No. 3, Jan. 1999.