Photogenerated charges and surface potential variations investigated on single Si nanorods by electrostatic force microscopy combined with laser irradiation

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Abstract

Photogenerated charging properties of single Si nanorods (Si NRs) are investigated by electrostatic force microscopy (EFM) combined with laser irradiation. Under laser irradiation, Si NRs are positively charged. The amount of the charges trapped in single NRs as well as the contact potential difference between the tip and NRs' surface is achieved from an analytical fitting of the phase shift - voltage curve. Both of them significantly vary with the laser intensity and the NR's size and construction. The photogenerated charging and decharging rates are obtained at a timescale of seconds or slower, indicating that the Si NRs are promising candidates in photovoltaic applications

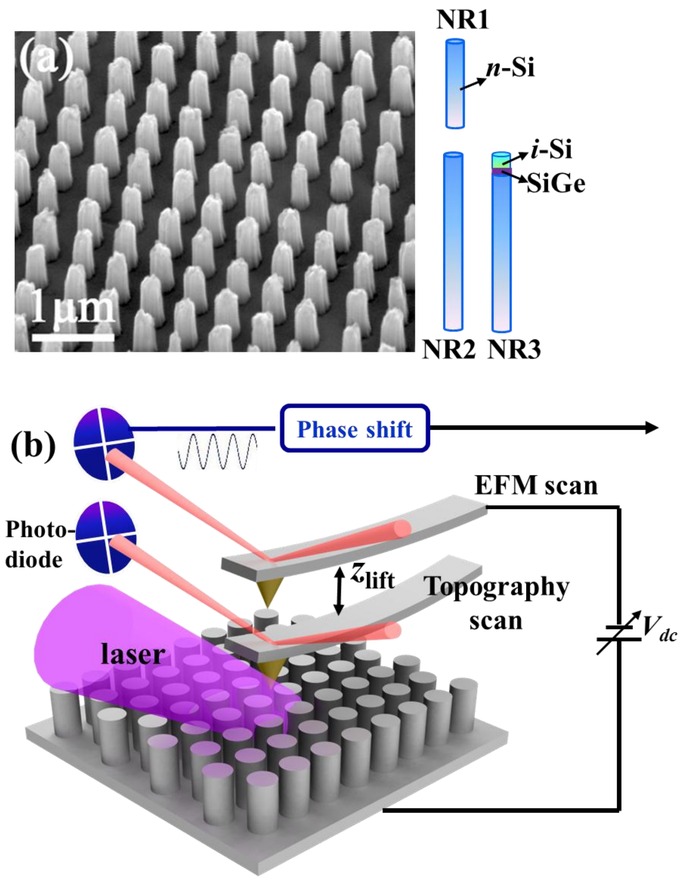

Figure 1 Constructions of NRs and schematic diagram of EFM measurements

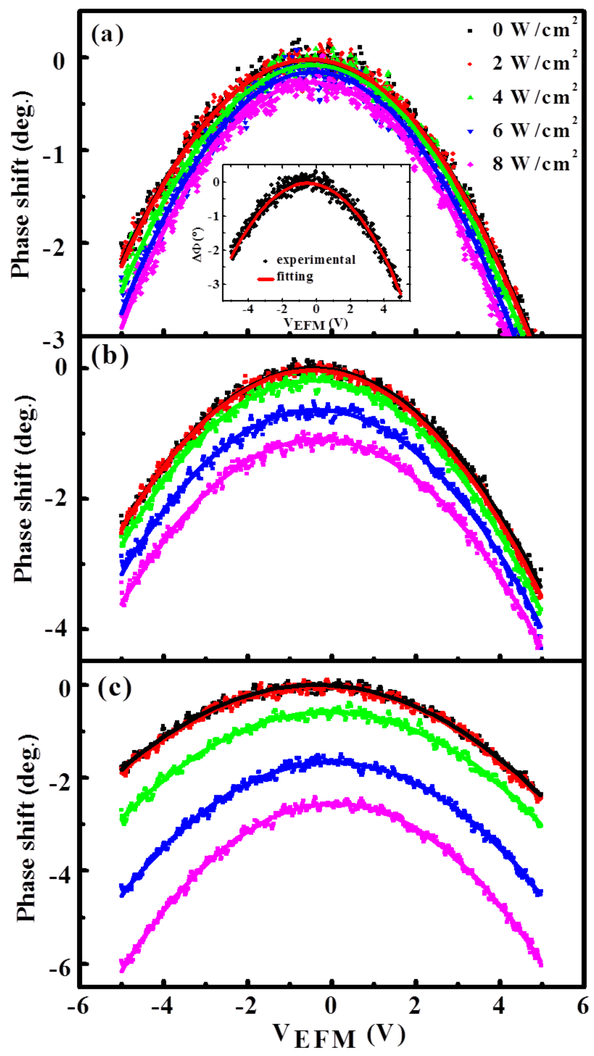

Figure 2 $\Delta\Phi - V_{EFM}$ curves measured at different laser intensities for NR1 (a), NR2 (b), and NR3 (c)..

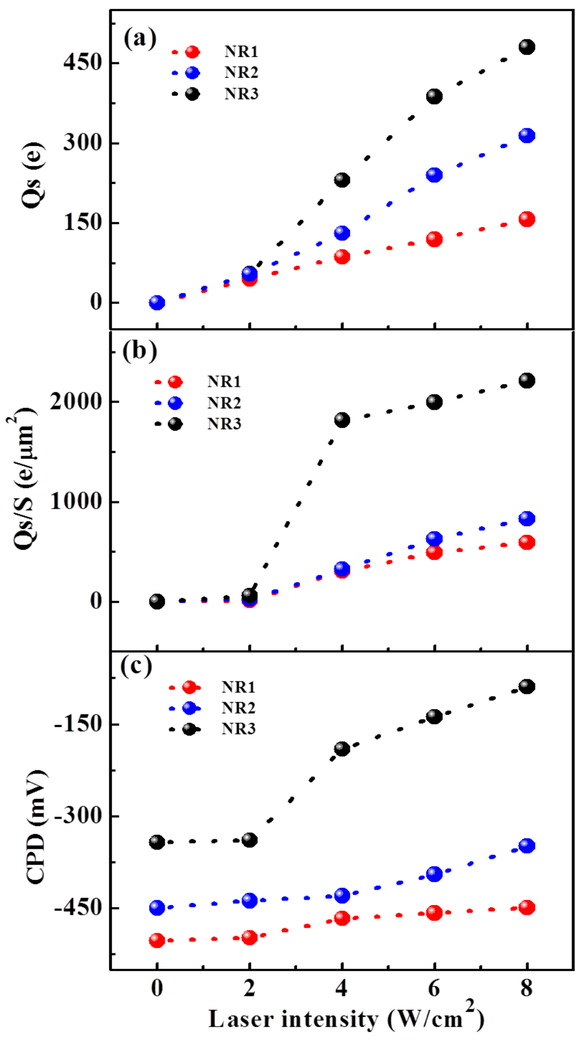

Figure 3 The trapped charges Q_s (a), charge density (b) and CPD values (c). Of the three samples as a function of laser intensity.

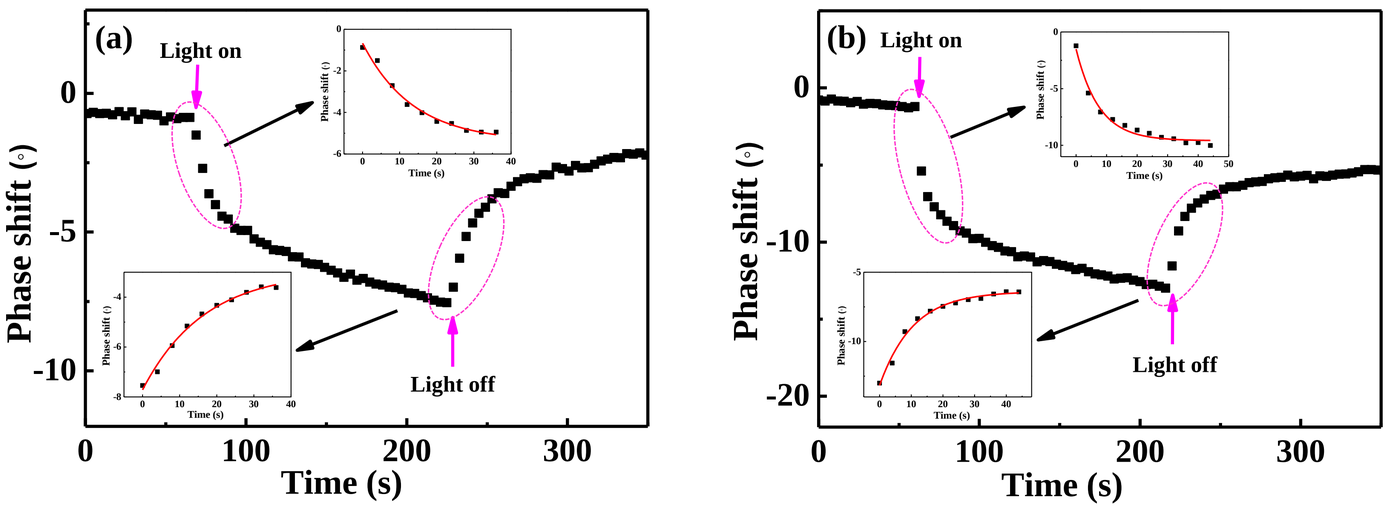

Figure 4 Time evolutions of EFM phase shift. Of NR2 (a) and NR3 (b) The exponential decay and growth fittings of the data when the laser is ON and OFF are given in the insets of the figure

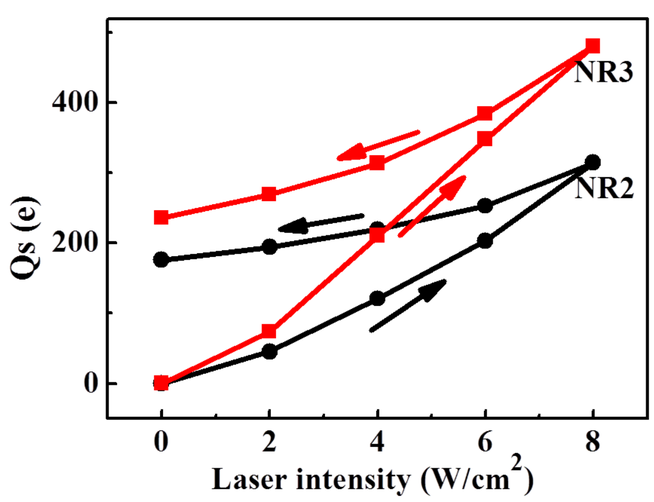

Figure 5 Hysteresis effect of photogenerated charges in NR2 and NR3.

Conclusion

The photogenerated charging and trapping phenomena are directly measured on single Si NRs without the deposition of electrodes by the means of EFM combined with laser irradiation. The amounts of photogenerated charges trapped in single NRs and the CPD values are obtained from the analytical fitting of $\Delta\Phi - V_{EFM}$ curves. The quantities of charges and CPD values are found to increase with the laser intensity and vary with the type of NRs. Though the exact mechanism for explaining the photogenerated effects of single Si NRs is not variable at present, it is clear that photoexcitation can lead to obvious charges trapped in Si NRs and hence reduce the work function of NRs. Therefore, EFM can provide an effective way to gain direct information on the trapped charges and surface potential of single nanostructures by combining with laser irradiation, which should be important for both basic understanding and potential applications of nanostructures in optoelectronics and photovoltaics.