Negative photoconductivity of n-doped Si nanowire field-effect transistors

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Abstract

Negative photoconductance is a rare effect, since the photoexcitation of charge carriers in e.g. metal or semiconductor materials normally enhances the channel conductivity. However, the inverse photoconductance in 0- or 1-dimensional nanostructures have been shown recently, as a consequence of the surface effects, such as surface plasmonic change in Au nanoparticles [1], photon assisted oxygen desorption on the surface in p-type ZnSe nanowires [2] and light induced hot-electron trapping of oxide surface in n-type InAs nanowires [3]. In spite of the enormous research and industrial demands for photovoltaic and solar cell application, the similar phenomenon has not been reported yet in silicon low dimensional structures.

In this study, we have studied the negative photoconductivity (NPC) of Si nanowire field-effect transistors (FETs) (Fig. 1(a)) with different doping concentration. N-doped devices show NPC behavior unlike undoped devices which have normal positive photoconductivity (PPC) by photoexcitation of electrons in Si NWs (Fig. 1(b)). The NPC originates from the number of channel carriers trapped by dopants, which are tuned by gate bias. The distinguishing feature of NPC of doped Si NWs is that the impurity trap is dominant source apart from the interfacial trap, contrary to other nanostructures. In addition, we have investigated NPC change with various illumination intensity and wavelength of light. Finally, the NPC and the PPC components are extracted respectively, which have exponential dependency with light power intensity. This study would be very promising for both tunable optoelectronics and sensor application by surface charge engineering with functional molecules.

References

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Figures

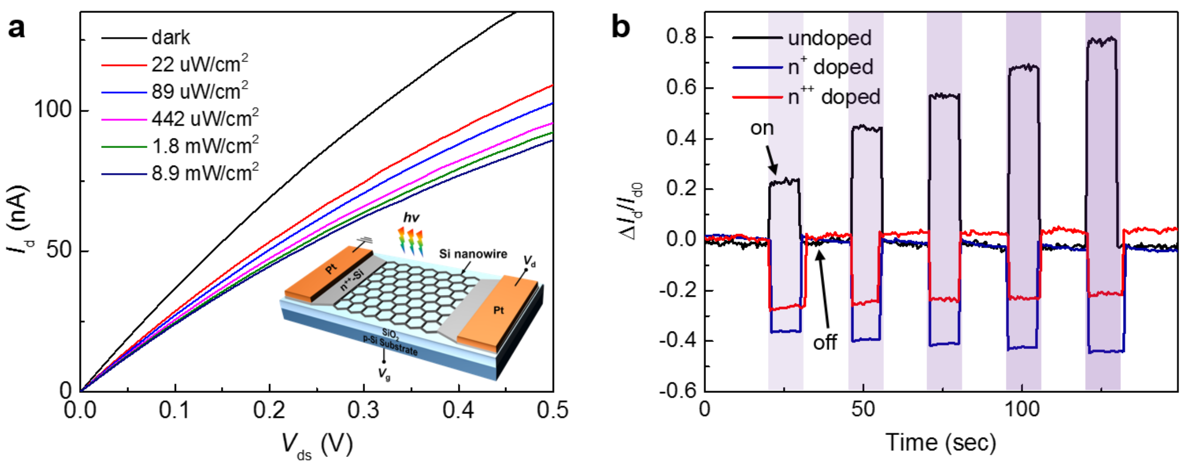

Figure 1 (a) I-V_{ds} curves of Si nanowire devices with various illumination intensity, Inset: schematic diagram the device, (b) Photoresponsivity ($\Delta I_d/I_{d0}$) change of Si nanowires FETs with different doping concentration by increasing light power intensity.