Optical properties of double-gated silicon nanowire FETs

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The optical properties of an array of silicon nanowire p^+-p-p^+ field-effect transistors are investigated. Thicknesses of front and buried oxide layers are 8 nm and 145 nm, NW length and thickness are 20 μm and 250 nm, correspondingly. The concentration of acceptors (boron) in both substrate and NW is 10^{15} cm^{-3} and in p^+ source and drain regions 10^{19} cm^{-3}. The peculiarities of source-drain photocurrent over a wide spectrum range are analyzed. It is shown that the absorbance of p-Si NW shifts to the short wavelength region compared with bulk silicon. The photocurrent reaches increased values in the UV range of the spectrum at 300K. Light and dark current-voltage characteristics and spectral dependences are measured at room temperature. The spectral photoresponse of Si NW FET structures is measured using monochromator YM-2. For the irradiation, we used incandescent lamps, positioned at 15 cm from the structure. NW samples are investigated in the wavelength range 0.25-0.6 at irradiation density 1.1 W/cm^2 and 1.6 W/cm^2, respectively. The effect of spectral shift in Si NW was explained as follows.

- The NW width (250 nm) limits absorption of the long-wave photons.
- As opposed to bulk silicon, the energy gap of the Si NWs increases while the NW size decreases.
- Internal quantum yield for Si increases and becomes 2-3 at quantum energy $h\nu \geq 3$eV.
- The color of the emitted light is determined by the choice of the nanoparticle (quantum dot, NW) characteristic size L, since $h\nu = E_g+E_e+E_h$, where E_g is the semiconductor bandgap energy, and the electron and hole confinement energies, E_e and E_h, respectively, become larger while decreasing. As absorption and radiation are conjugating processes then the shift of the absorption spectra to the short-wave range can also be related to this fact. With decreasing size, the short-wave photons can be more effectively absorbed in SiNWs.

Therefore, Si NW FETs can be successfully used as UV photodetectors.