Supporting Information

Monolithic axial and radial metal-semiconductor nanowire heterostructures

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Photo-response of the ultra-thin Si-shell and wavelength dependent photocurrent measurements:

To elucidate the nature of the photoconductive response of the ultrathin semiconducting shell, a further Ni top contact (TC) was fabricated contacting selectively the ultrathin Si-shell wrapped around the c-Al core. The SEM image in supporting figure 1a shows the resulting coaxial metal-semiconductor-metal (M-S-M) structure with the crystalline semiconducting layer sandwiched between the c-Al NW and the Ni top contact. Applying a bias between the Al core NW and the TC enables a sensitive photo-response measurement due to the high electric field and the extremely short diffusion path of photo-generated electron-hole pairs in the ultra-thin semiconducting shell. The overlay in supporting figure 1a shows the measured photocurrent as a function of the position of a focused green laser beam scanning along the NW. As the laser spot (beam diameter is 865 nm) is much broader than the Ni contact (L_{TC} = 300 nm) the photocurrent reaches its maximum when the laser spot is centered over the TC, due to effective charge carrier separation in the Si-shell at the Schottky contacts between the c-Al core and the outer Ni contact.

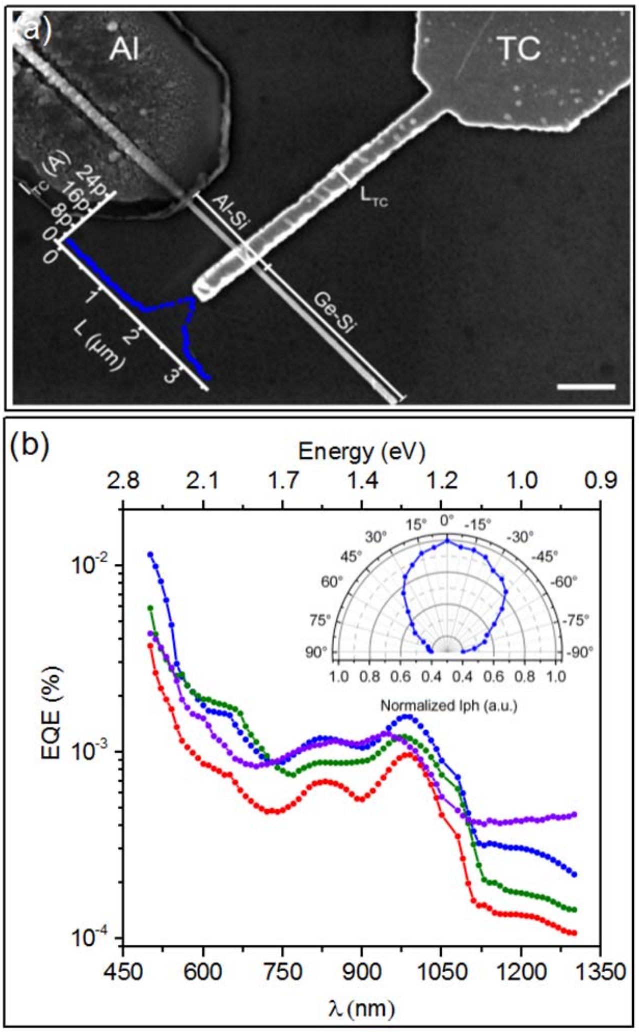

Figure S1. *(a) SEM image of a c-Al-Si core-shell NW with additional Ni top contact to the Si-shell. Scale bar is 1 µm. The inset shows the photo-response as a function of the position of the laser beam scanning along the NW heterostructure. The photocurrent measurements were recorded for a green laser (λ = 532 nm), a laser power of E_L = 100 µW/µm² and a bias voltage of V_{TC} = 1.7 V with the Al contact pad grounded. (b) Spectral photosensitivity measurement of four representative devices in the wavelength range between λ = 500 nm to 1300 nm. The inset shows the polarization dependence of the photocurrent for a wavelength of λ = 532 nm, a laser power of E_L = 100 µW/µm² and a bias voltage of V_{TC} = 1.7 V. All measurements were conducted at room temperature and ambient conditions.*

Further, the spectral photosensitivity of this Si-tube wrapped around the c-Al core NW was evaluated by wavelength dependent photocurrent measurements in the visible and near infrared regime. The spectral photosensitivity of four representative devices is displayed in supporting figure 1b. Most remarkably, deviating from bulk Si, below $\lambda = 700$ nm a large increase of I_{ph} was reproducibly detected independent of the investigated c-Al core NW diameters. This is in agreement with simulations of confinement effects in ultrathin Si NWs, where the electronic and excitionic gap are significantly expanding for decreasing diameters below 4 nm.[1] Further, the polarization dependence of the photocurrent of the thin tube-like Si shell is shown in the inset of supporting figure 1b. Parallel excitation i.e. the laser polarization along the NW axis, generates the highest current, with a ratio of the maximum to minimum photocurrent of $I_{ph\ max} / I_{ph\ min} = 2.46$. We dedicate this anisotropy to the dielectric mismatch[2] between the tube like shell and the surrounding dielectric (air), which results in a more efficient optical excitation under the incidence of linearly polarized light parallel to the NW axis.[3,4] Thus, we devote the increase of the photocurrent for lower wavelength (< 700 nm) of the quasi-1D Si-tube to band-gap modifications present in ultrathin Si layers[1] rather than a transformation of polarization-dependent Mie resonances into polarization-independent Fabry-Pèrot-like resonances.[5]

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