Extended and local phonon mode identification in a silicon nanowire by 1/f noise spectroscopy

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Abstract
Current has been injected into a suspended, boron-doped silicon nanowire (Fig. 1a, 200nm length and 16.9nm diameter) and the voltage (V) developed across its terminals has been Fourier transformed. 1/f–like noise spectra were found. Since nanowire I-V characteristic is linear (Ohm law valid), the normalized noise intensity (S_V/V^2) should be independent of voltage. By contrast, we show that local deviations from the Ohm's law occur in S_V/V^2 vs. V at voltages corresponding to phonon energies of both silicon and impurities existing in nanowire [1].
The nanowire has been "scanned" in the (0<V<100)mV voltage range, with a ΔV=0.5 mV voltage step, at room temperature. The dependence of S_V/V^2 vs. V is shown in Fig. 2. Although the structure in noise is complicated, one can observe the existence of some dominant peaks at 18.54, 57.34, 76.72 and 79.35 mV, respectively. A comparison with the silicon phonon spectrum, measured by inelastic tunneling spectroscopy at 4.2K [2] and 0.8K [3], respectively, revealed that the most intense noise peaks at 18.54 and 57.34 mV correspond to the transversal TA and TO extended phonon modes in silicon, respectively. The noise peaks at 76.7meV and 79.3meV correspond to 76.9meV and 79.9meV local vibration modes of boron in silicon lattice, respectively [4]. The total number of boron atoms in the nanowire was estimated at 3. Apparently, the method is sensitive to a few atoms in the nanowire matrix. Also, the far infrared local modes of the interstitial oxygen were identified at V<7meV (not shown). 14 hours after measurement, the nanowire was broken (Fig. 1b), most probably due to the high current density (>10^7A/cm^2) in it.
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References
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Figures

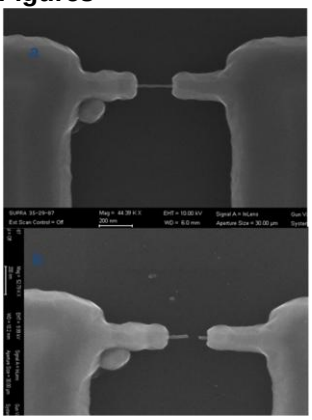

Fig. 1. SEM images of the nanowire before (a) and 14 hours (b) after measurements

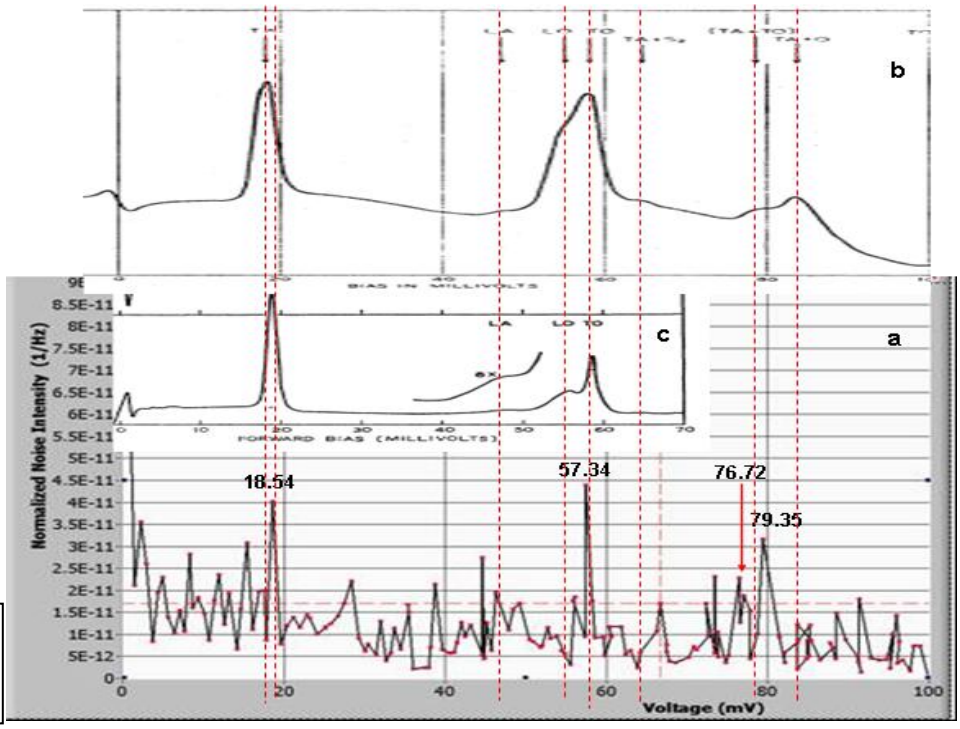

Fig. 2- Noise data (a) vs. tunneling spectra at 4.8K [2](b) and 0.8K [3] (c)