Supplemental Material: Ultimate Conductivity Performance in Metallic Nanowire Networks

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1. Normal distribution of junction resistances

Although homogeneous networks can be used to describe the conducting properties of networks in a rather simplified way, it is reasonable to expect that in reality a certain degree of dispersion is present in the junction resistance distributions. To describe the random nature of junction resistance values associated with the networks, the resistance matrix $\hat{M}_R$ was also built assuming a normal distribution of junction resistances characterized by a mean value $\langle R_j \rangle$, a spread σ and truncated within the interval (0,+∞). A configurational average comprising 30 sets of junction resistance distributions averaged over the same geometrical framework of the network sample was performed and the results are shown in Figure S1. One can notice that the R_s vs. $\langle R_j \rangle$ curves are no longer entirely linear. This is a consequence of the asymmetry of the distribution; one cannot assign negative values to the junction resistances. NWNs are highly disordered systems and the specifics of their interwire junctions depend on a multitude of factors such as wire surface coating, work function, and contact arrangement. In other words, microscopic randomness and uncertainty factors are inherent within their synthesis. It is rather unlikely that they are described by perfectly symmetric normal distributions. The spread of the distribution alters the value of the characteristic junction resistance R_j^{exp} determined from the interception point between the measured sheet resistance and the numerical curves. This variation occurs in both modeling schemes however, it can be more pronounced for samples treated within MNR. This is due to the fact that MNR sets the characteristic junction resistances at considerably lower (and more realistic) range of values than those predicted by JDA. The later tends to overestimate junction resistances since it does not include the influence of the background medium.

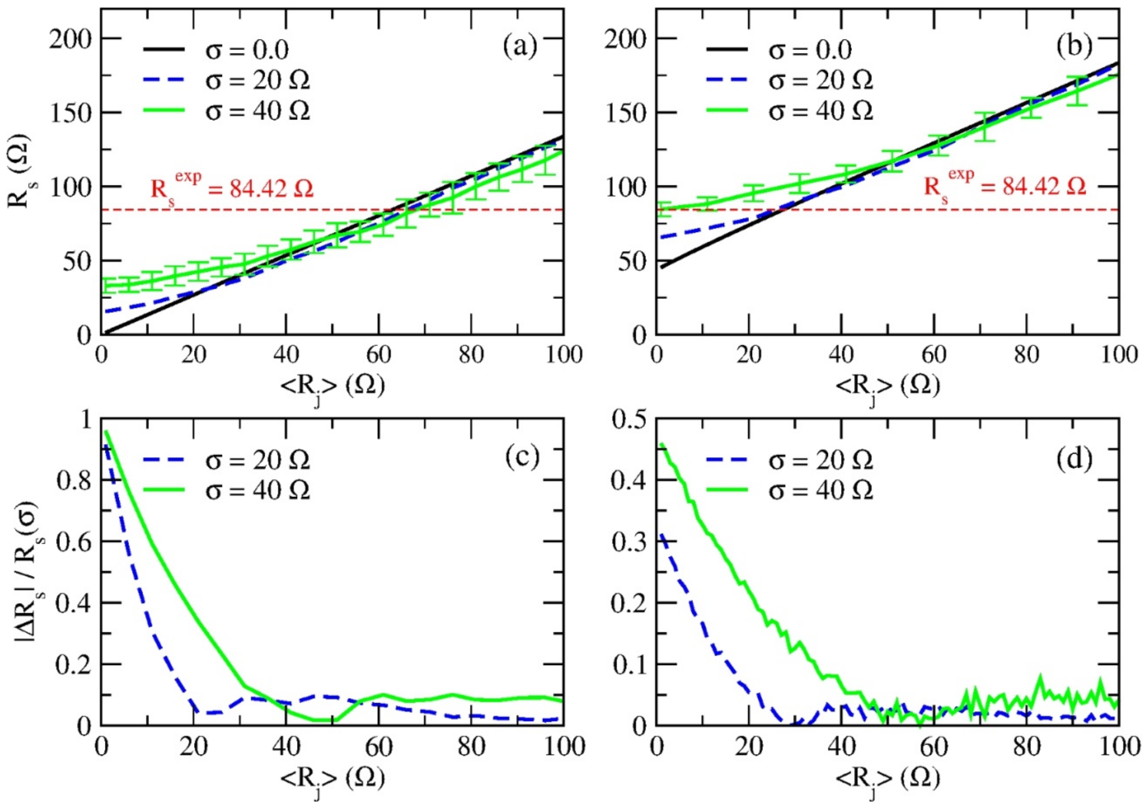

Figure S1: (Color online) (top panels) Sheet resistance (R_s) versus junction resistance (R_j) analysis performed on sample #6 using JDA (left panels) and MNR (right panels) models. Junction resistances were assigned within homogeneous description (σ = 0) and following a normal distribution characterized by its mean value ($<R_j>$) and spreading (σ ≠ 0). For better visualization, error bars are only shown for σ = 40 Ω. Horizontal dashed lines (red) mark the measured sheet resistance value. (bottom panels) Relative sheet resistance variance versus mean junction resistance computed from the curves displayed on the top panels.

Figure S1 also reveals the role played by the spreading in the junction resistance distributions on the sheet resistances of the networks. Although we cannot determine how dispersive the junction resistance distributions are (σ is unknown for all samples), this study allows us to distinguish the main contributions to the sheet resistance. So far, the homogeneous description within MNR isolates two main contributions, one depending on the absolute value of R_j and another due to material properties associated to R_0. However, randomness in the junction resistances can also contribute to the total sheet resistance of the networks. The bottom panels of Figure S1 shows the relative variation in the sheet resistance with respect to the systems with and without spreading. This is obtained by subtracting the curves with and without dispersion, $\Delta R_s = |R_s(\sigma) - R_s(\sigma=0)|$, and dividing it by $R_s(\sigma)$. Strong variations in the sheet resistance are observed when the characteristic junction resistance is relatively low with respect to the amount of spread.

2. Set of parameters and characteristics of all 30 Ag NWNs samples

Table S1: Wire densities (n), characteristic junction resistances (Δ/a_0) of all Ag NWN samples obtained by fitting the measured sheet resistance (R_s^{exp}) with the calculated curves R_s vs. R_j derived within MNR. Values of Δ, R_0 as well as the optimization-capacity coefficient (γ) are also depicted.

Network	n (NW/μm^2)	γ	Δ (Ω)	Δ/a_0 (Ω)	R_0 (Ω)	R_s^{exp} (Ω)
#1	0.28	0.45	37.99	27.73	46.43	84.42
#2	0.16	0.42	67.90	27.52	92.05	159.95
#3	0.16	0.65	116.15	60.07	60.99	177.14
#4	0.49	0.31	5.94	13.38	12.86	18.80
#5	0.64	0.49	11.67	43.39	12.09	23.77
#6	0.35	0.82	147.58	152.00	32.91	180.50
#7	0.63	0.40	5.94	35.03	8.90	14.85
#8	0.47	0.55	11.58	52.52	9.30	29.89
#9	0.17	0.32	18.28	15.28	37.90	56.20
#10	0.39	0.51	34.42	33.96	32.85	67.27
#11	0.20	0.69	161.72	69.89	71.42	233.15
#12	0.57	0.59	30.13	51.01	20.93	51.06
#13	0.17	0.76	168.40	125.88	52.14	220.54
#14	0.37	0.35	11.95	22.71	22.03	33.98
#15	0.14	0.60	117.18	61.57	77.15	194.33
#16	0.26	0.51	28.14	38.33	26.39	54.54
#17	0.24	0.44	22.20	26.60	28.18	50.38
#18	0.12	0.61	66.42	67.47	42.70	109.12
#19	0.21	0.05	3.19	2.28	58.68	61.88
#20	0.29	0.51	21.36	38.25	20.78	42.15
#21	0.28	0.34	18.73	23.33	35.44	54.17
#22	0.14	0.32	33.14	15.76	70.48	103.62
#23	0.35	0.36	12.68	23.92	21.97	34.65
#24	0.29	0.54	22.30	43.68	19.19	41.49
#25	0.37	0.66	38.50	56.78	19.81	58.31
#26	0.36	0.59	25.24	53.03	17.68	42.93
#27	0.43	0.59	23.10	48.18	16.23	39.33
#28	0.35	0.43	24.10	21.98	32.02	56.12
#29	0.19	0.65	121.52	51.74	66.52	188.04
#30	0.22	0.50	38.64	38.54	38.04	76.68

3. Add-on: electrical measurements in single Ag nanowire and networks

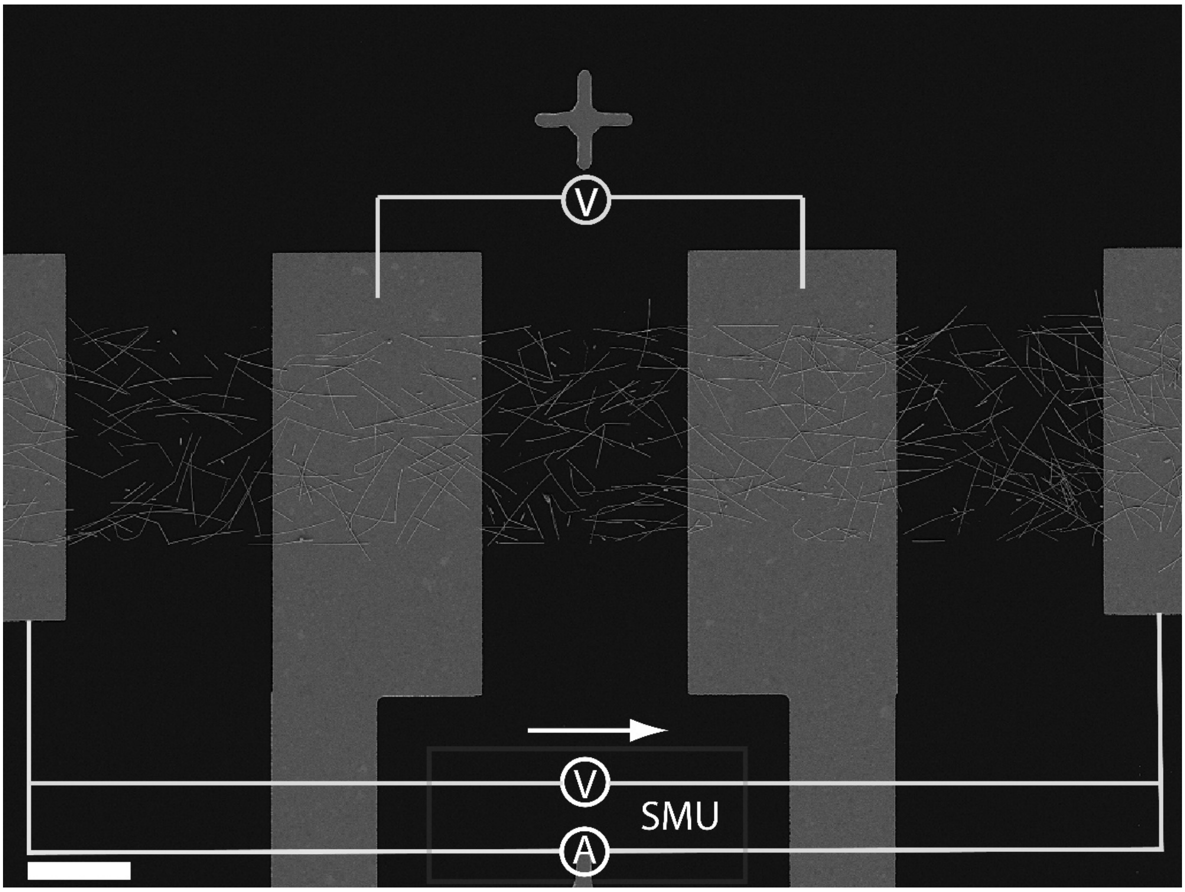

Figure S2: By sourcing current across the outer most contacts, and measuring the corresponding voltage drop across the network (the inner two electrodes) the contact resistance is removed from the measurement. Scale bar (bottom left) represents 10 µm.

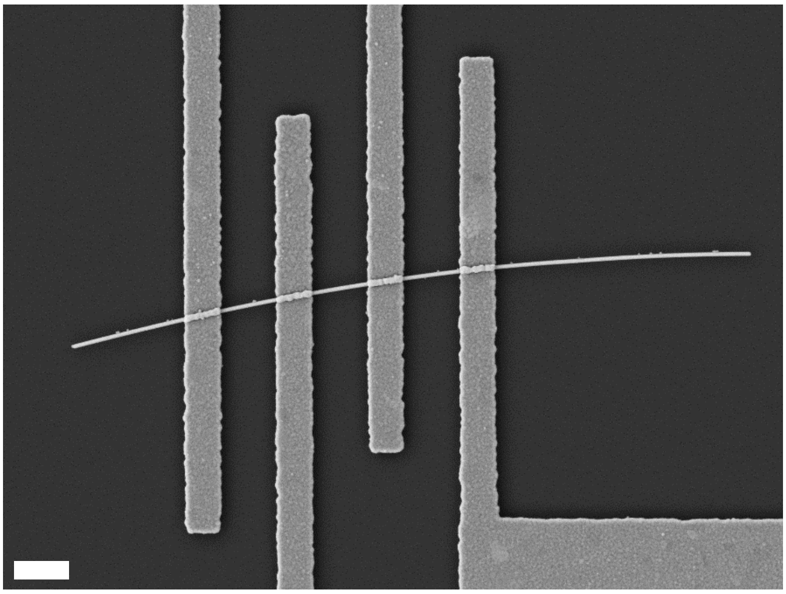

Figure S3: : Contacted single Ag NW using the 4-wire measurement from which its physical dimensions and wire resistivity can be obtained. Scale bar (bottom left) represents 1 µm.

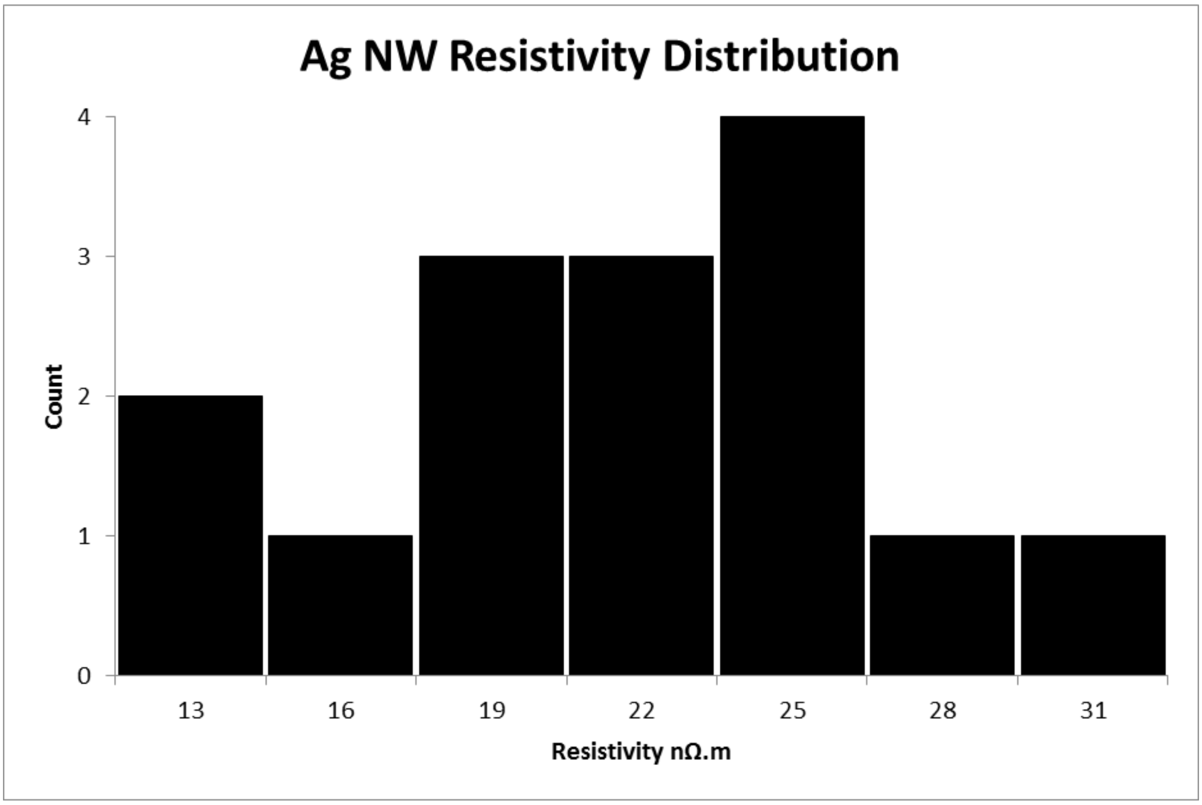

Figure S4: Resistivity distribution built from 15 single Ag NW samples. The average resistivity is <ρ> = 22.6 ± 2.3 nΩ.m. The main source of error from this measurement was the variance along the nanowire when taking multiple diameter measurements.

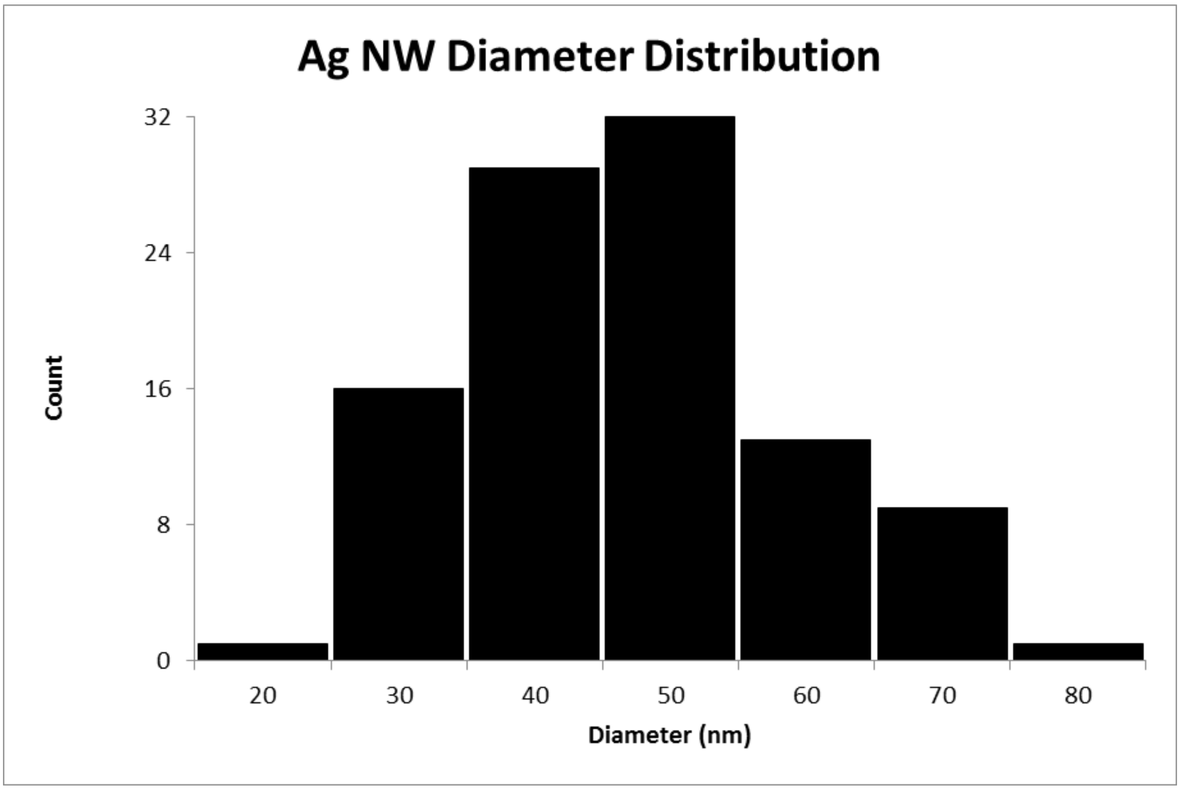

Figure S5: Distribution of diameters taken from 101 Ag NW samples measured using SEM. Average diameter is <D> = 50 ± 13 nm.