Supporting Information for "Co-percolation To Tune Conductive Behaviour in Dynamical Metallic Nanowire Networks"

J. A. Fairfield[a,c,†], C. G. Rocha[b,c], C. O'Callaghan[b,c], M. S. Ferreira[b,c] and J. J. Boland[a,c,*]

[a.] *School of Chemistry, Trinity College Dublin, Dublin 2, Ireland.*
[b.] *School of Physics, Trinity College Dublin, Dublin 2, Ireland.*
[c.] *Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, Dublin 2, Ireland.*
†Present address: School of Physics, National University of Ireland Galway, University Road, Galway, Ireland.

1. Nanowire Density in Networks Measured Experimentally

TABLE SI. Nanowire densities for experimental nanowire networks of varying compositions of Ni/Ag.

Nanowire composition Ni/Ag	Nanowire density (NW/μm^2)
100/0	0.22
93/7	0.25
85/15	0.19
70/30	0.30
68/32	0.24

2. Arithmetic versus Geometric Mean for Ni-Ag Nanowire Junctions

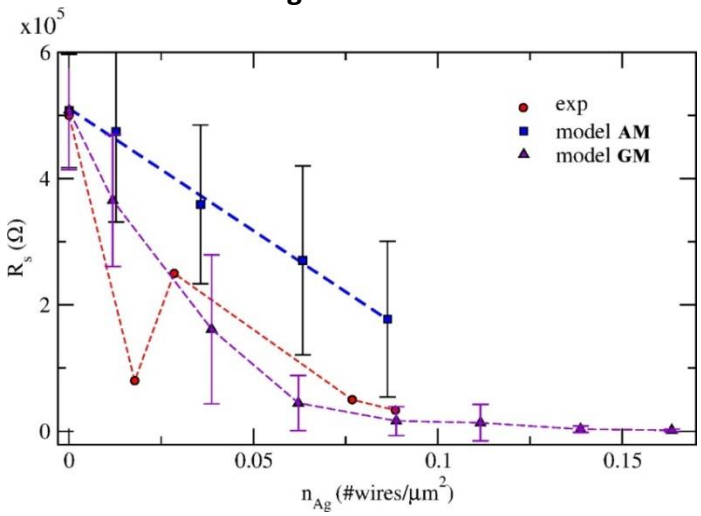

Figure S1. Sheet resistance (R_s) versus Ag wire density (n_{Ag}) calculated for nanowire networks with a total wire density of n = 0.25 nanowires/μm^2. Results are shown considering that the hybrid junction resistance R_j^{NA} is written in terms of (squares) an arithmetic mean (AM) or (triangles) a geometric mean (GM) of R_j^{NN} and R_j^{AA}. Circles correspond to measured values. The experimental sample has dimensions of 100 x 100 μm.

Figure S1 shows how the calculated sheet resistances compare with the experimental values as the concentration of Ag nanowires increases. Simulations were performed considering that the hybrid Ni-Ag junctions are modelled within arithmetic mean (AM) or geometric mean (GM) representation. As a result of their better conducting attributes, Ag nanowires tend to lower the sheet resistance of Ni nanowire networks as evidenced by experiment. More importantly, the reduction is substantial and it can be achieved with relatively small concentrations of Ag wires. The decrease in R_s is non-linear and its trend is completely captured by our numerical description following GM representation. On the other hand, AM scheme predicts a spurious linear dependency between R_s and n_{Ag}. Therefore, it is clear that GM enables a meaningful evaluation of the transport properties of hybrid nanowire networks. For sets of highly discrepant values such as the experimental nanowire junction resistances, GM dampens the influence of the highest numbers providing less biased, more accurate results for the calculated averages.

3. Dynamical activation of Ni/Ag nanowire networks

The files c6nr06276h3.mpg, c6nr06276h2.mpg, and c6nr06276h1.mpg show the full dynamical activation of a pristine Ni NWN sample and hybrid ones with Ni/Ag = 95/5%, and Ni/Ag = 75/25%, respectively. Stars indicate junctions that were activated at each simulation step. Charge is loaded on the electrodes until a path of activated junctions bridges them. All wires composing this path are highlighted in blue at the end of the animation. FIG S2 shows some snapshots of the corresponding animations.

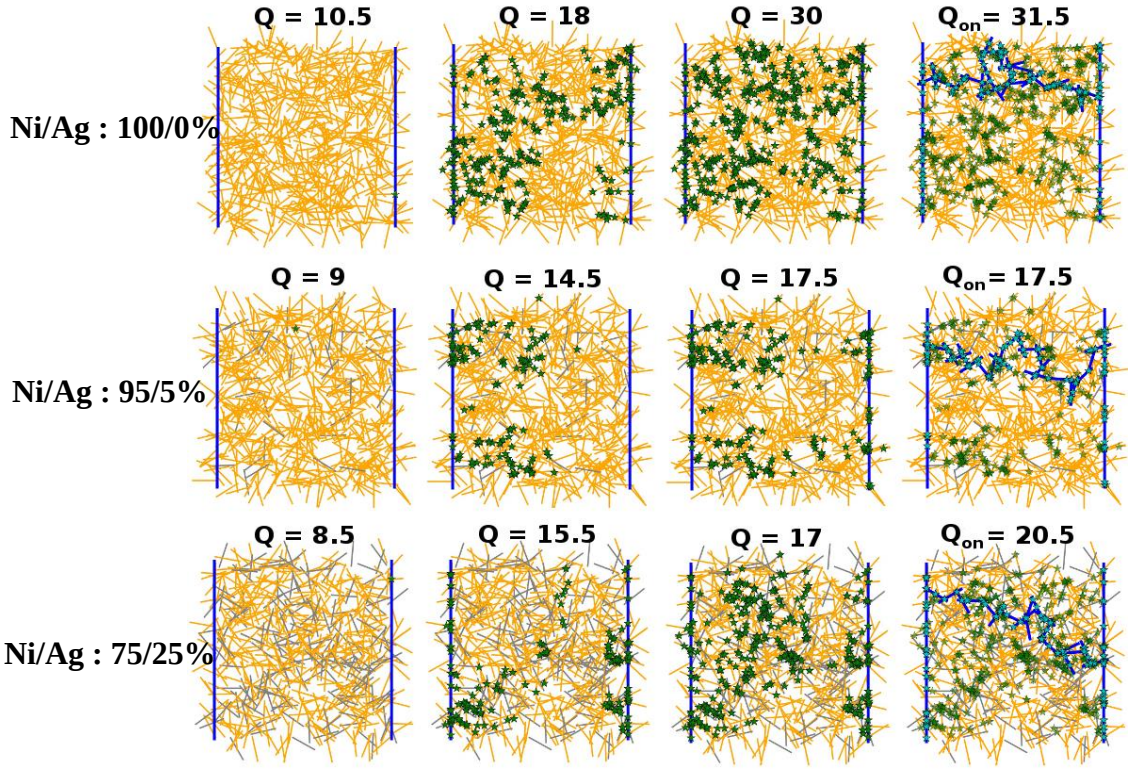

Figure S2. Snapshots of the dynamical activation of a (upper panels) pure Ni nanowire network, and hybrid networks containing Ni/Ag fractions of (middle panels) 95/5% and (lower panels) 75/25%. Green stars represent junctions that were activated to its ON-state as charge (Q) is loaded into the electrodes. Eventually a path of ON-state junctions bridges the electrodes (blue path) evidencing that current can finally flow through it. The amount of charge required to enable this path is given by Q_{on} specified in terms of arbitrary units. All networks have fixed density of n = 0.25 nanowires/μm^2 and dimensions 50 x 50 μm.

4. Activation of Ni/Ag nanowire networks: increasing capacitance contrast

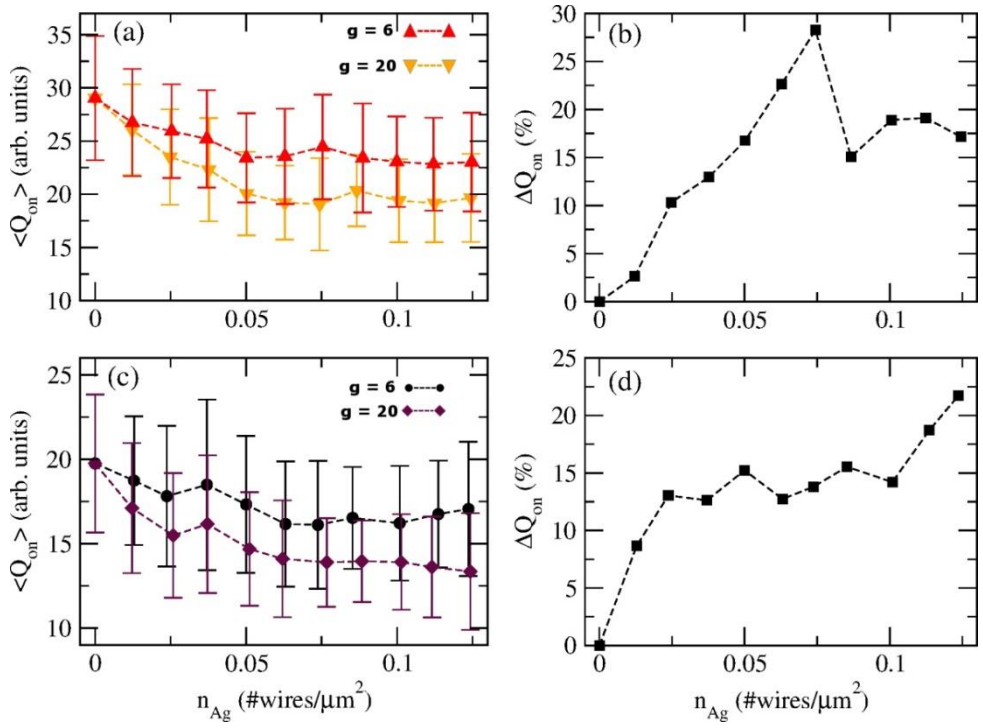

Figure S3. (Left panels) Average amount of charge required to establish a percolative path of activated junctions (<Q_{on}>) on Ni/Ag nanowire networks as a function of Ag wire density (n_{Ag}) for (a) d = 50 μm and (c) d = 35 μm. Each data point is a result of statistical ensembles containing 50 representative networks of sizes d x d and fixed wire density of n = 0.25 nanowires/μm^2. The parameter g is the proportionality constant which defines the capacitance contrast of the wires, i.e. $\boldsymbol{C^{OFF}(Ag) = gC^{OFF}(Ni)}$. (Right panels) Percent relative error in <Q_{on}> taken from the curves g = 6 and g = 20 on the left panels (ΔQ_{on}) as a function of n_{Ag}. Panel (b) corresponds to the case where d = 50 μm whereas (d) corresponds to d = 35 μm.