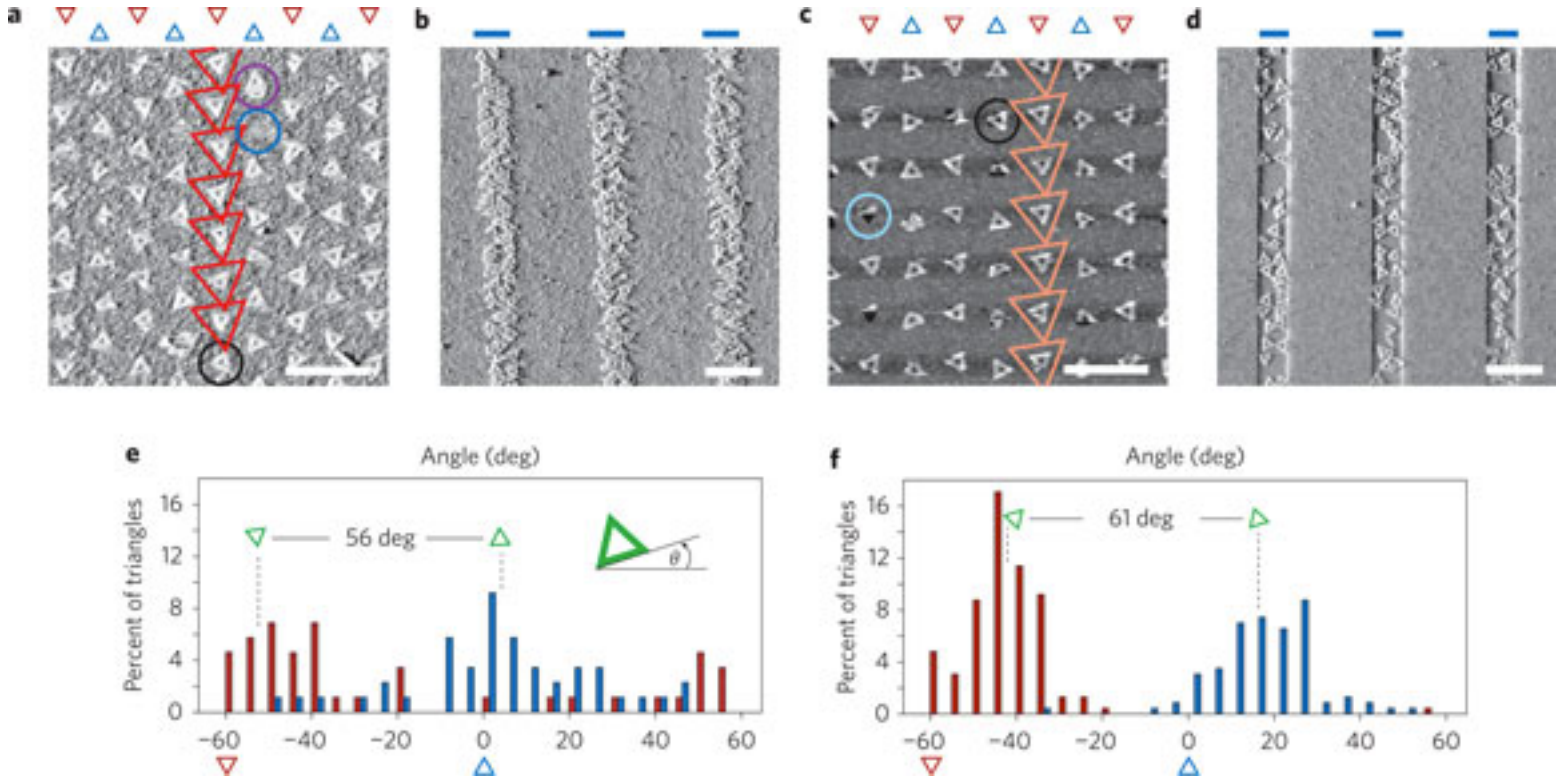
Placement and orientation of individual DNA shapes on lithographically patterned surfaces



Scale bars are 500 nm

Rothemund & al.
Nature Nanotechnology 4, 557 - 561 (2009)
doi:10.1038/nnano.2009.220

Using DNA for nano-electrode functionalization

- Electrochemical functionalisation
- Hybridization of complementary fluorescent strands
- Each nano-electrode is 100–500 nm wide and separated by a gap of 1µm

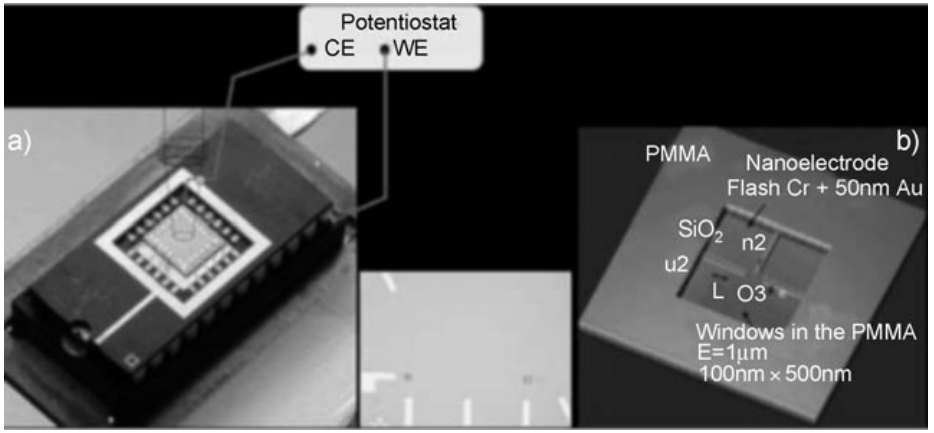
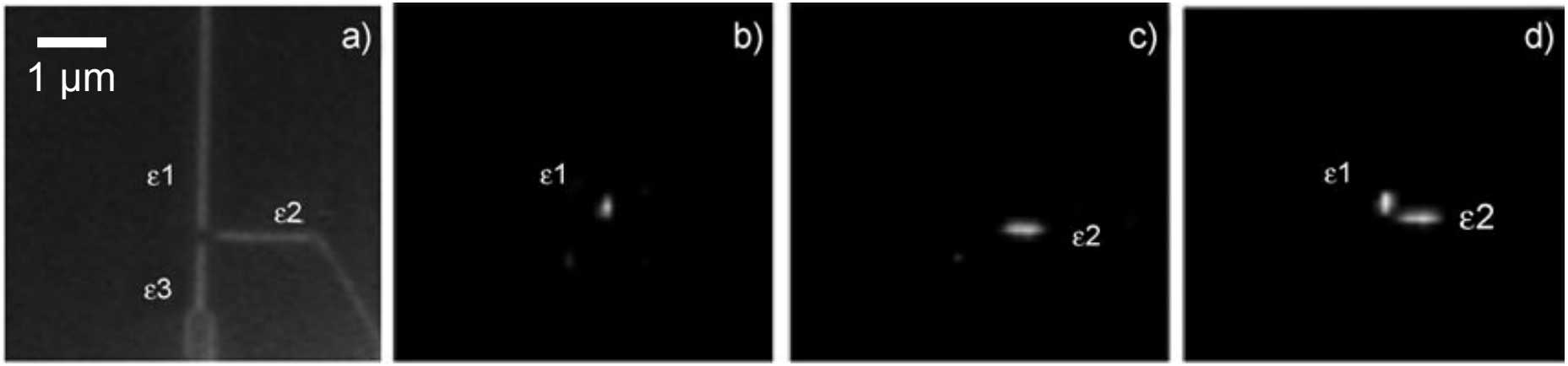
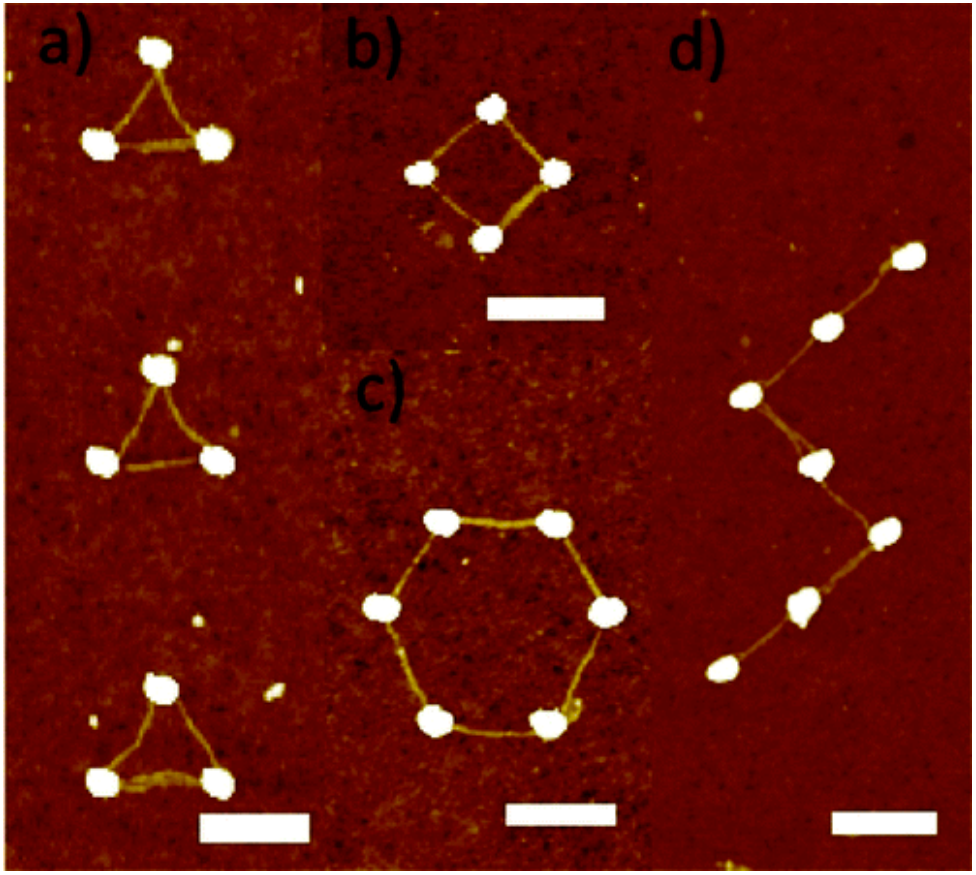


Figure 1. a) Schematic representation of an electrospotting microcell superimposed to the chip carrier image and chip's optical image. b) Schematic view of a nanoelectrode array (α1, α2 and α3) displaying characteristic dimensions. One can distinguish the opening on the PMMA insulating layer that defines the effective electrochemical cell as well as the electrode length.

Descamps, *ChemPhysChem* **2010**, 11, 3541 – 3546



Using DNA for connecting (wiring) nanometric Au islets



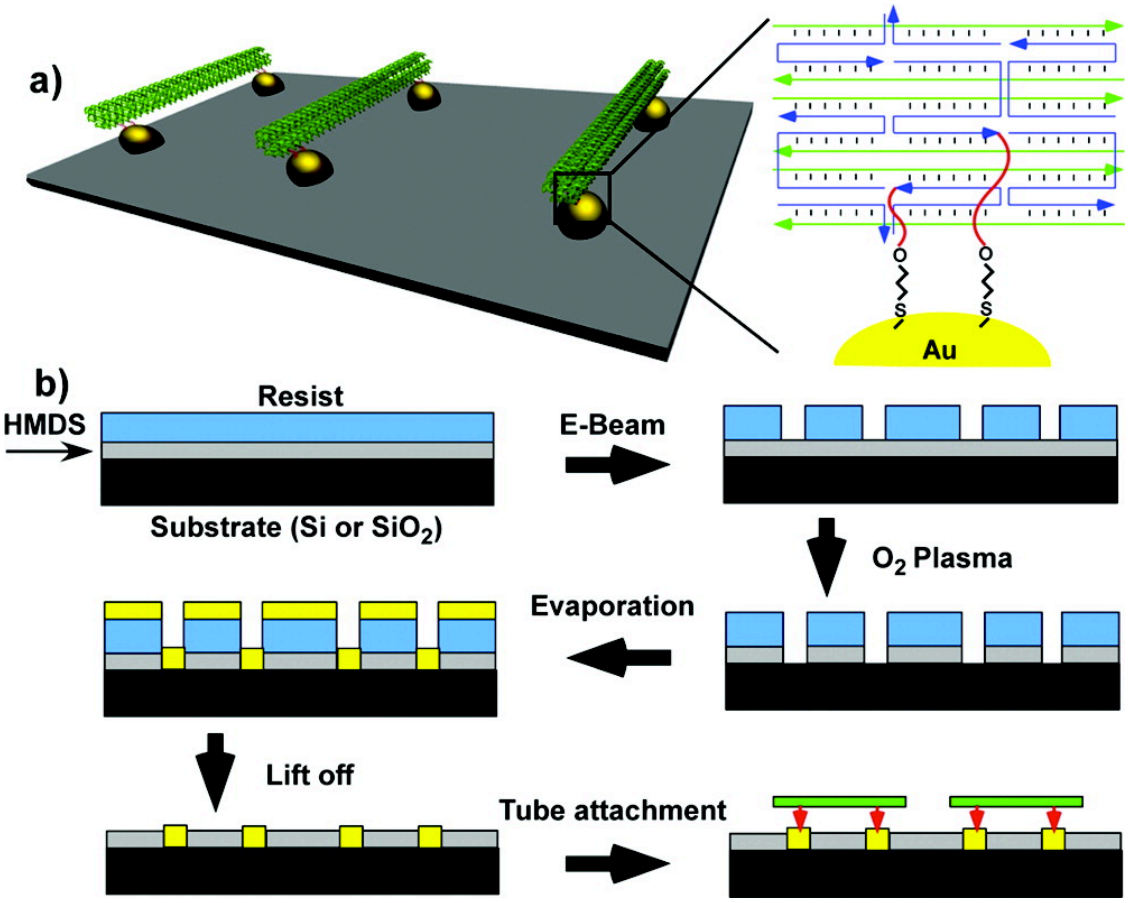
Scale bars are 300 nm

- DNA bundles
- The diameter of the DNA tubes is about 7 nm; the gold islands' diameter ranges from 40 nm to 80 nm with a height of 20 to 30 nm.
- For AFM imaging, the sample was on a Si surface
- AFM tapping-in-air

Nano Lett., **2010**, 10, 5065–5069
DOI: 10.1021/nl1033073

Using DNA for connecting (wiring) nanometric Au islets

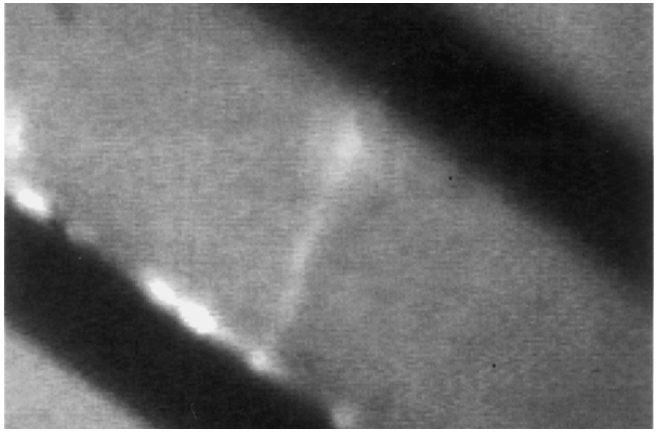
- Patterning of gold islets
- DNA origami nanotubes
- Thiolated oligos DNA pending on the origamis
- no electrical conductivity

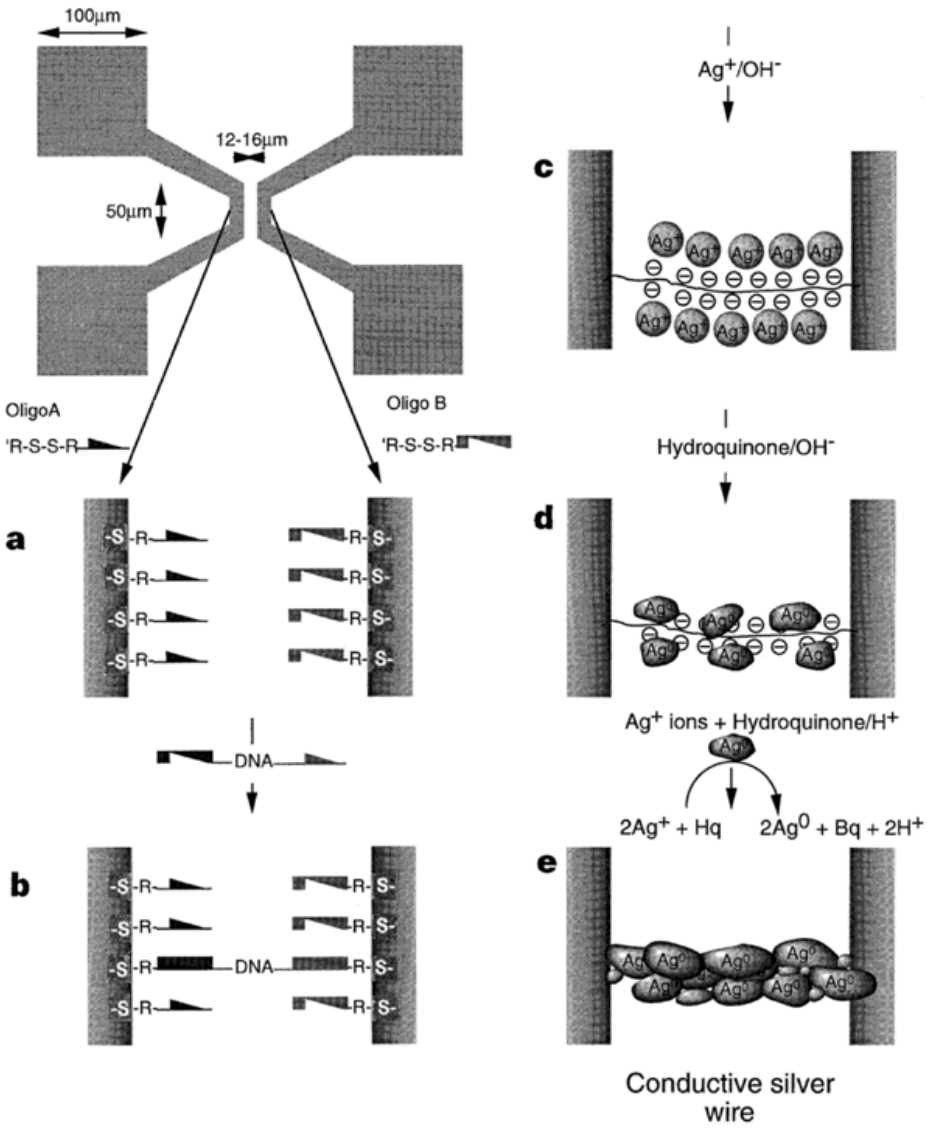


Nano Lett., **2010**, 10, 5065–5069
DOI: 10.1021/nl1033073

Metallization of nanowires: Inorganic growth on DNA

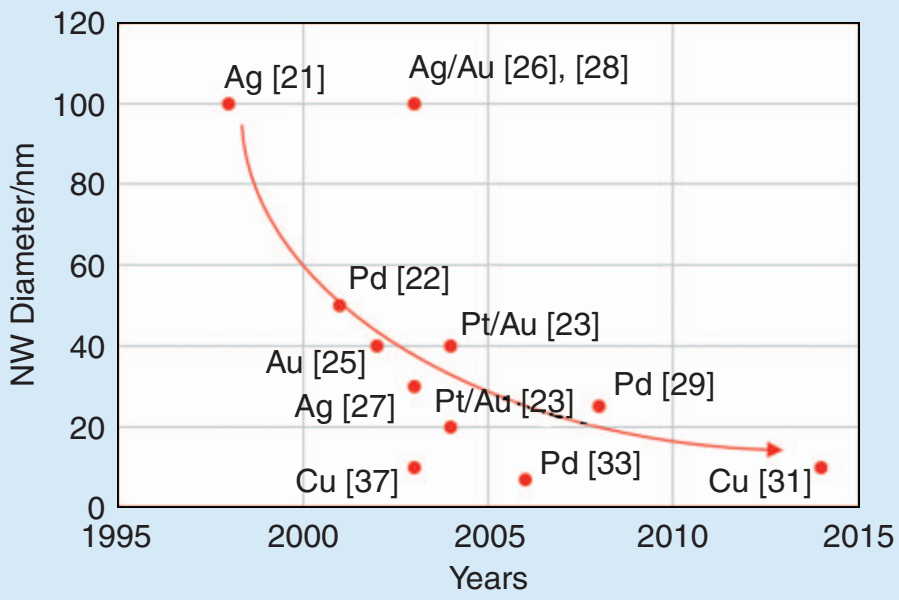
- First example in the litterature
- 2-step process, making silver NW
- 16 µm long, 100 nm large
- Fluorescent labelling of DNA:

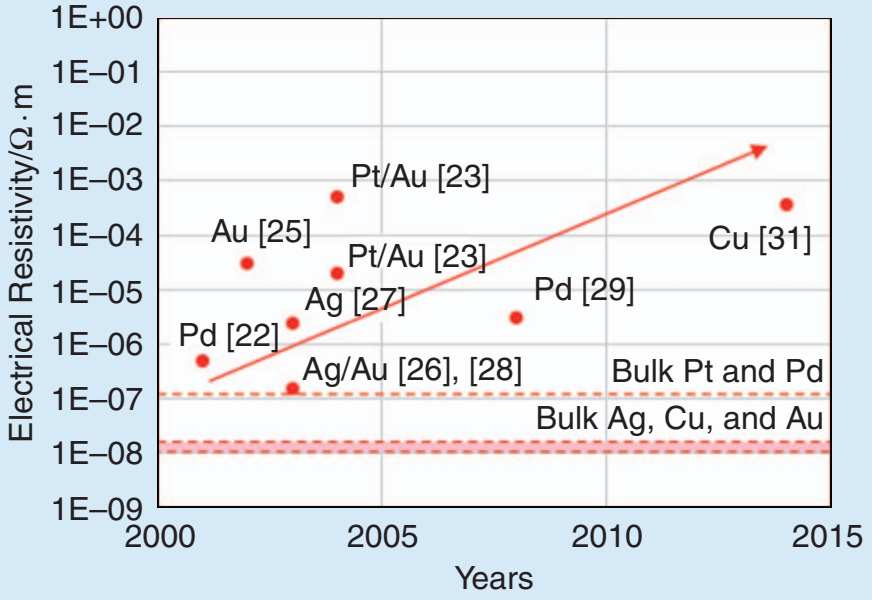




Nature **391**, 775-778 (19 February 1998)
doi:10.1038/35826

Metallization of nanowires: Inorganic growth on DNA





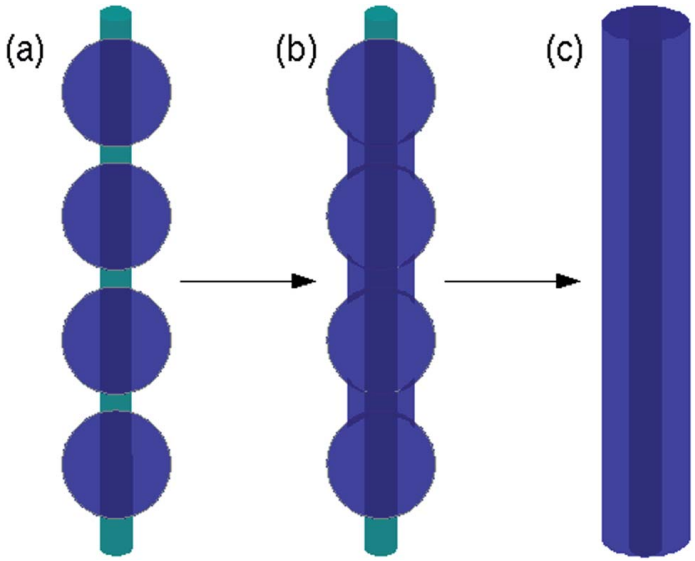
The fabricated NWs have made a compromise between their diameter and their performance. both targets could not be achieved at the same time because low-diameter NWs returned poor electrical performance.

C.Brun et al, IEEE Nanotechnology Magazine, Vol. 11 (1), 2017

Metallization of nanowires: Inorganic growth on DNA

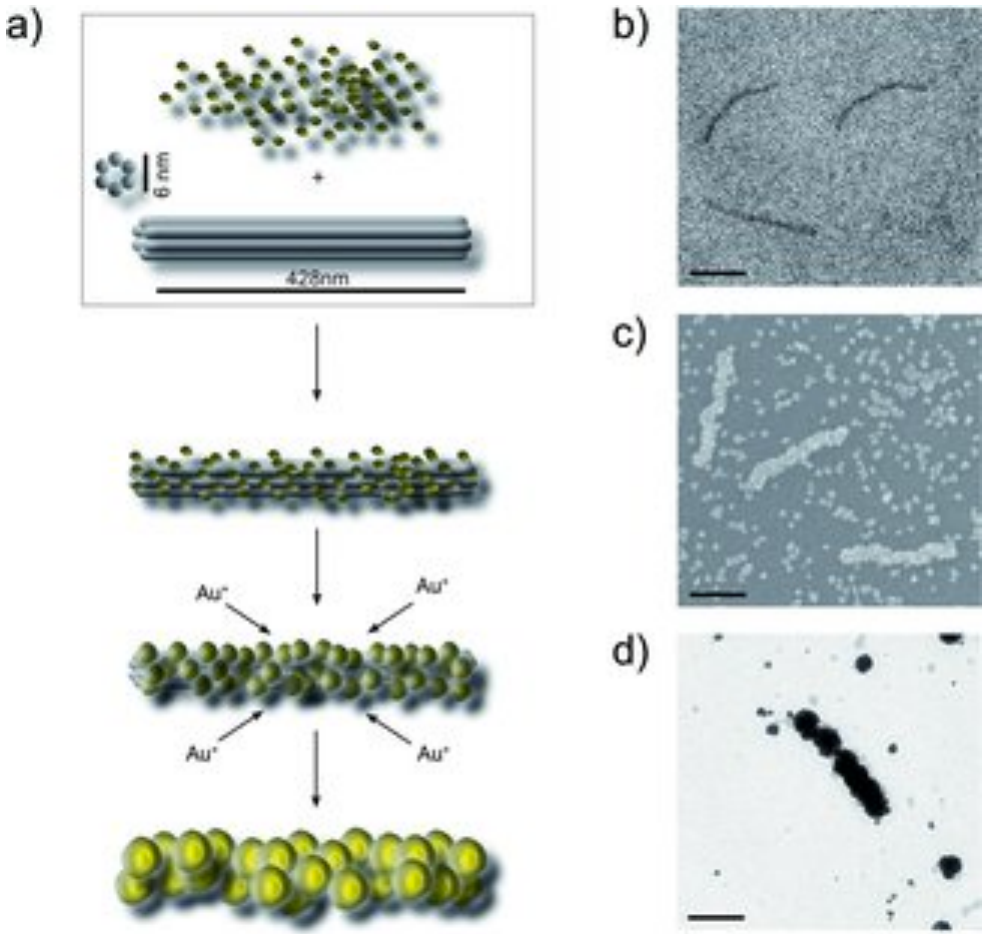
Starting with soluble metallic ions

- A broad range of metals have been templated on DNA; examples include Ag, Au, Pt, Cu, Ni, Fe, Co and Pd
- The typical reaction involves mixing DNA with a solution of a metal salt and then adding a reducing agent.
- The DNA may be dissolved in solution, or immobilised on a solid substrate.
- Metal ions bind strongly to DNA at a variety of sites by electrostatic interaction with the phosphate groups and by coordination to the nucleobases.



Nanoscale, 2014, **6**, 4027–4037 | **4029**

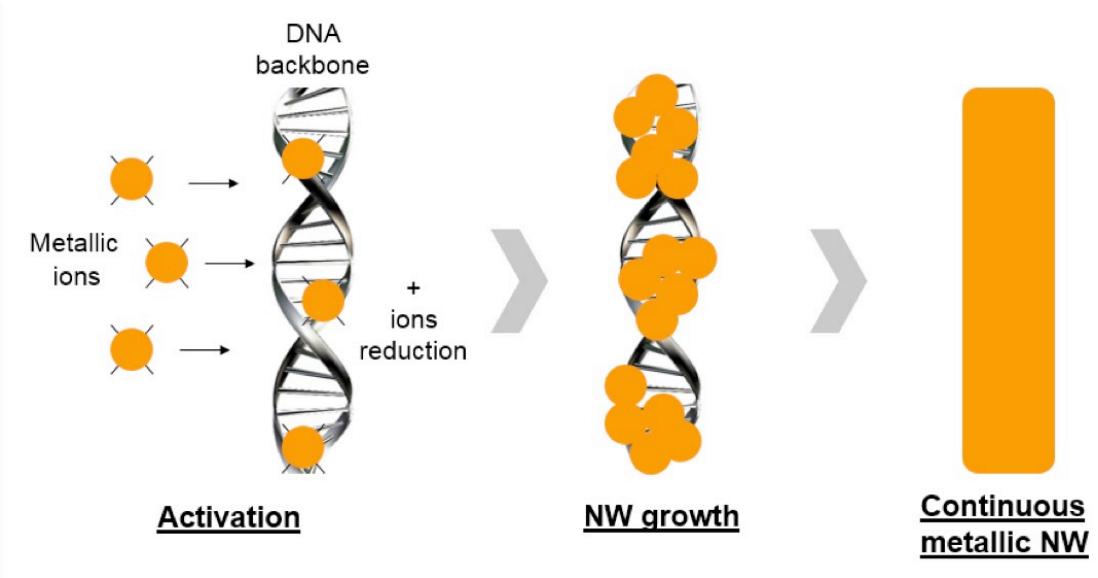
Inorganic growth – gold nanowires



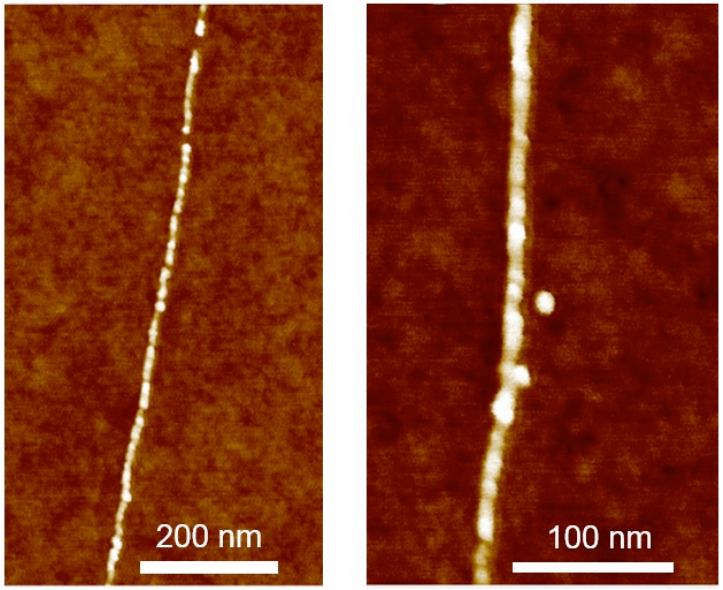
a) Metallization strategy. Positively charged gold clusters cover the negatively charged DNA origami structure. Continuous metallization of such pre-seeded DNA origami structures is achieved by the electroless deposition of gold ions to the electrostatically bound Au clusters. b) TEM image of native six-helix bundles stained with uranyl acetate. Successful metal deposition results in continuously metallized objects of defined shape and dimensions, which is revealed by SEM (c) and TEM (d). Gold cluster seeding was performed on substrate (c) and in solution (d). Scale bars 200 nm.

DOI: 10.1002/smll.201100465

DNA used as a template for Copper nanowire



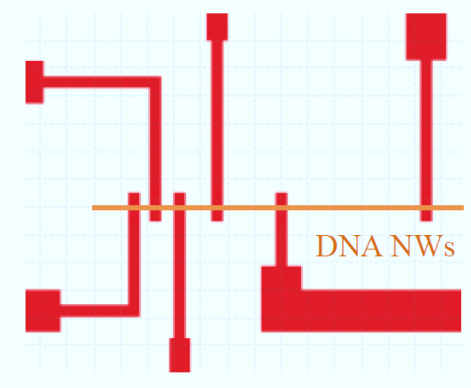
AFM images after Cu metalization



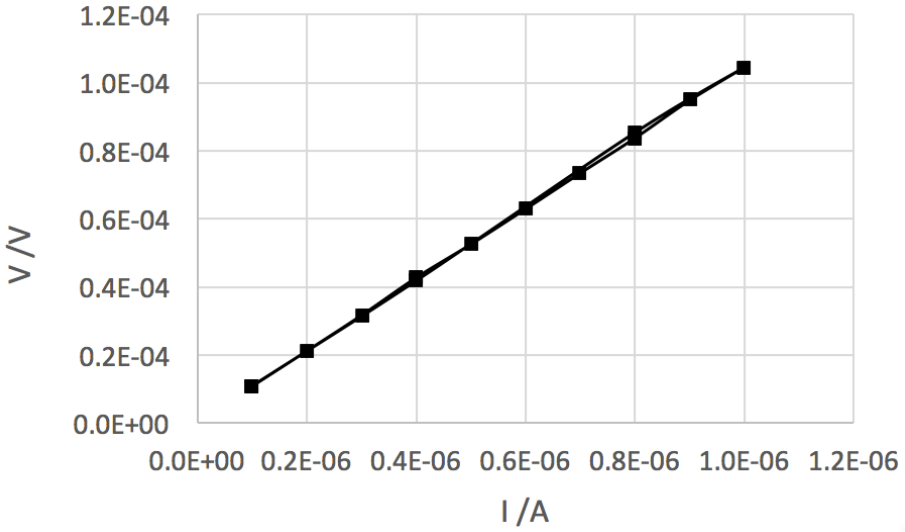
- Activation step: exchange of metallic cations on the DNA backbone
- 0.8 µM copper nitrate with 32 µM ascorbic acid for 3 h r.t. and pH 5.
- Gentle stirring was performed during all of the metallization process.
- Copper NW of 10-nm diameter with 5-nm high nWs were achieved
- Still some defects (no metal on some points)

C.Brun et al, IEEE Nanotechnology Magazine, Vol. 11 (1), 2017

DNA used a conducting nanowire

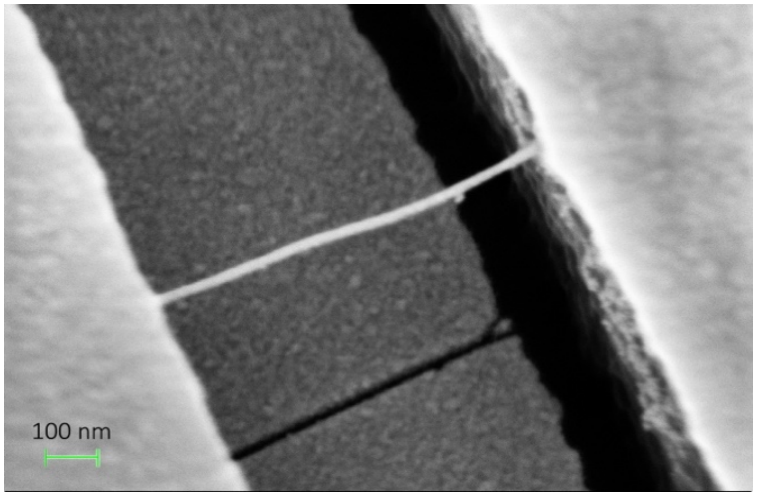


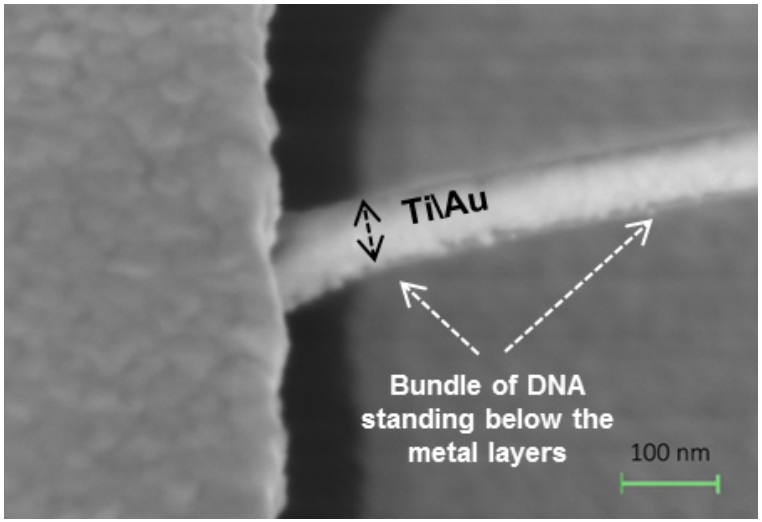
I/V curve for 80-nm diameter metallic NWs



The electrical NW conductivities extracted were at the same order as the bulk gold.

SEM images of the fabricated Ti/Au NWs from suspended DNA wires





DNA used a conducting nanowire

small 2015, *11,* No. 1, 134–140

(a) and (b) SEM image of a Au-coated DNA NW connecting two pillars,
(c) Current-voltage curves recorded from DNA NWs with 300 nm (thick) and 80 nm (thin) diameter coated by 30 nm of gold that connected two pillars.
(d) Current recorded from a thin Au-DNA NW until burning of the Au-DNA NW

As a (short) conclusion and take-home message

- DNA is a versatile organic material
- Cheap, tunable, easy synthesis
- Everything is based on its polymeric self-assembling properties
- Besides its original functionality, a LARGE panel of potential app.
- Data storage with remarkable performance although some automation are needed and long processing times
- Biosensing with DNA/RNA aptamer
- Nanoobject building for plasmonics, sensing, lithography
- And many other things to come, for sure…

Thank you for your attention,