# Addressing of Self-Assembled Nanoarrays via Randomized-Contact Decoders*

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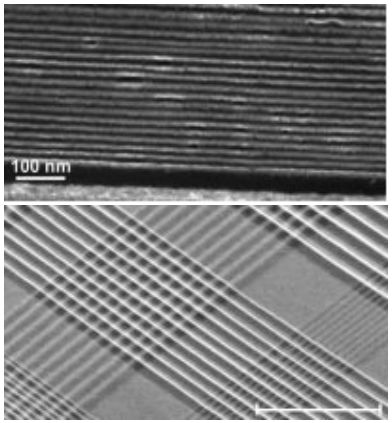
* Supported in part by NSF Grant CCF-0403674

# Working with Crossbars

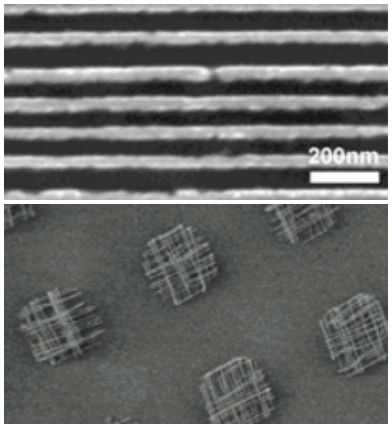
- Crossbars can serve as a basis for both memories and circuits.
- Nanowires (NWs) can be assembled into crossbars, but assembly is stochastic.
- Nanowire crossbars must interface with lithographically produced technology.
- Randomized-contact decoders (RCDs) provide an efficient defect-tolerant interface

# Uniform Silicon NWs

- Uniform NWs can be produced using a stamping process.
- They can also be grown off-chip with chemical vapor deposition.
- In both cases these NWs can be assembled into crossbars.
- To use these crossbar many NWs must be individually controllable.




SNAP NWs
(Heath, Caltech)

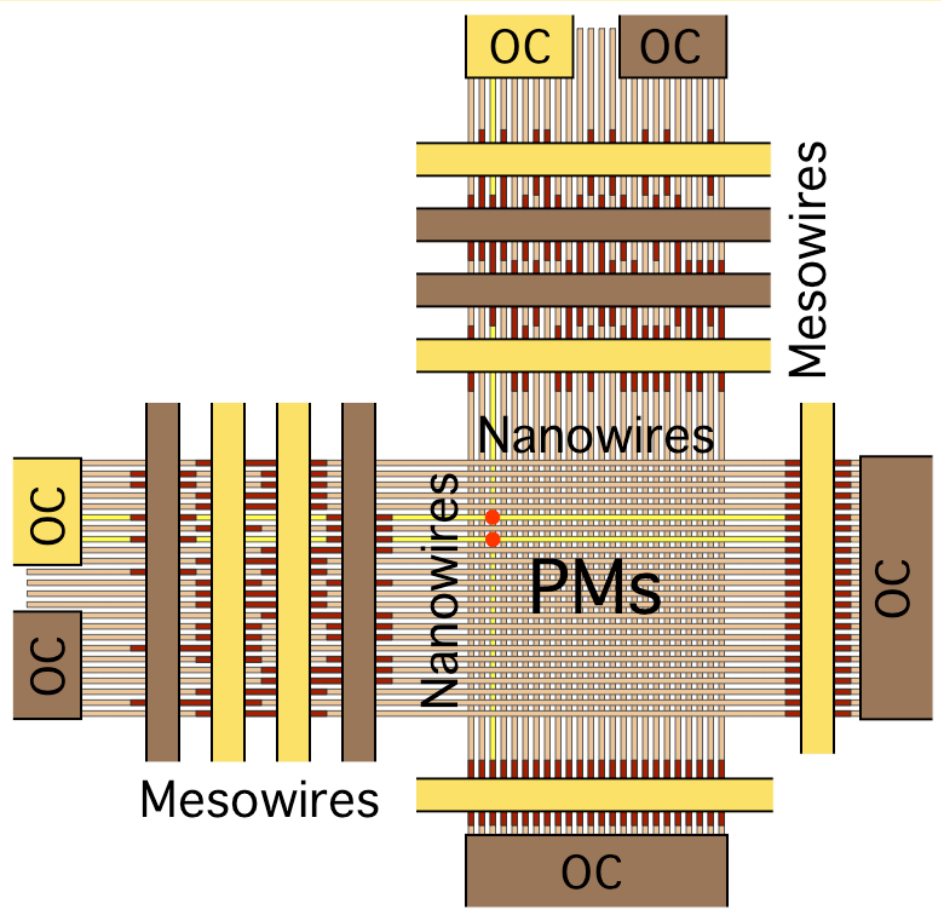



CVD NWs
(Lieber, Harvard)

# Controlling NW Crossbars

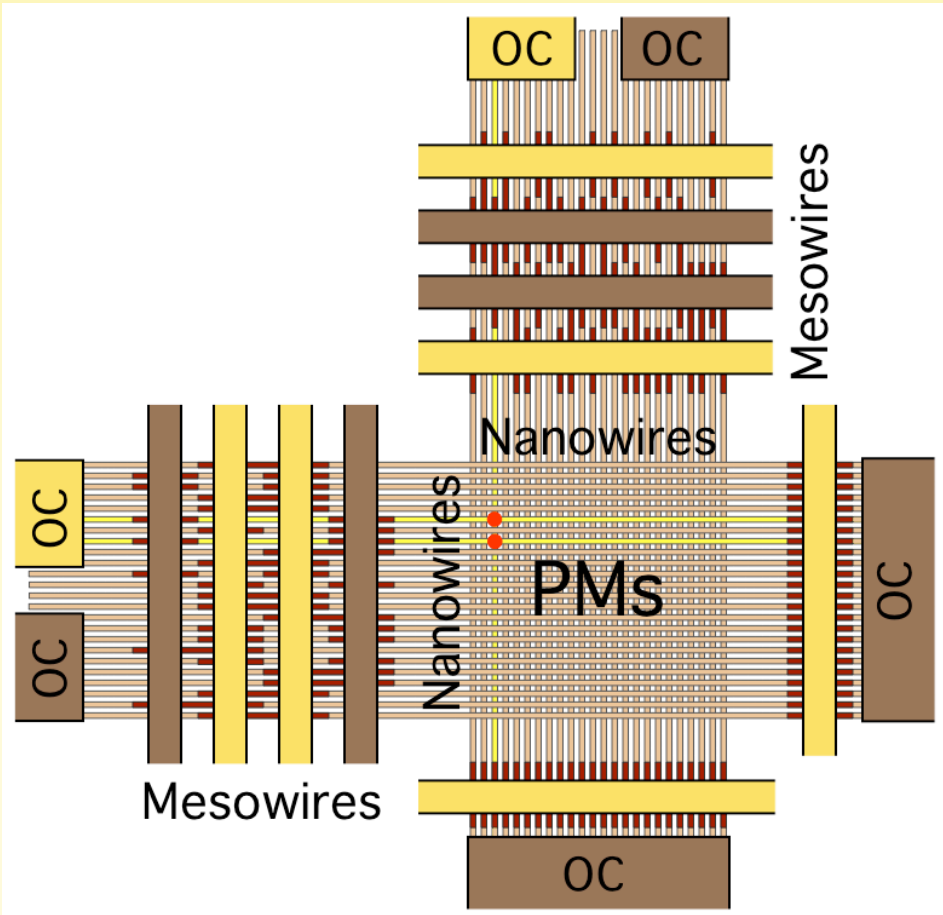
How much lithographic circuitry is required?

- ***Ohmic contacts*** (OCs) place a voltage across consecutive NWs.
- ***Mesoscale address wires*** (MWs) turn off NWs within each group.
- Lightly doped regions couple MWs to NWs.



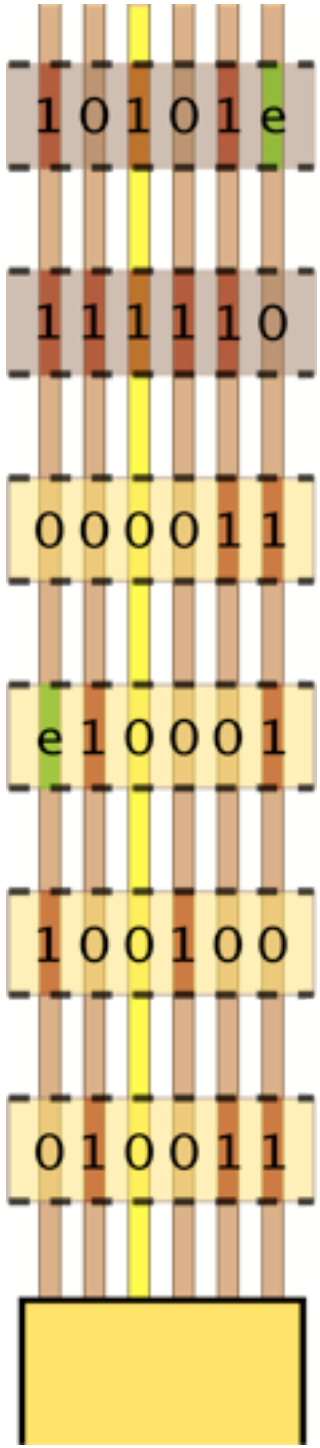
# Read/Write Operations

- Perpendicular NWs provide control over molecular devices.
- Larger voltages set the conductivity of crosspoints.
- Smaller voltages measure conductivity.



# Nanowire Decoders

- The interface between NWs and MWs is called a **NW decoder**.
- In a decoder each of *M* MW provides control over a subset of NWs.
- We associate an *M*-bit **codeword, $c_i$** with each NW. Let $c_{i,j}$ be the j$^{th}$ bit of $c_i$.
  - $c_{i,j} = 1$ if the j$^{th}$ MW controls the i$^{th}$ NW.
  - $c_{i,j} = 0$ if the j$^{th}$ MW has no effect on the i$^{th}$ NW.
  - $c_{i,j} = e$ if the j$^{th}$ MW partially controls the i$^{th}$ NW.

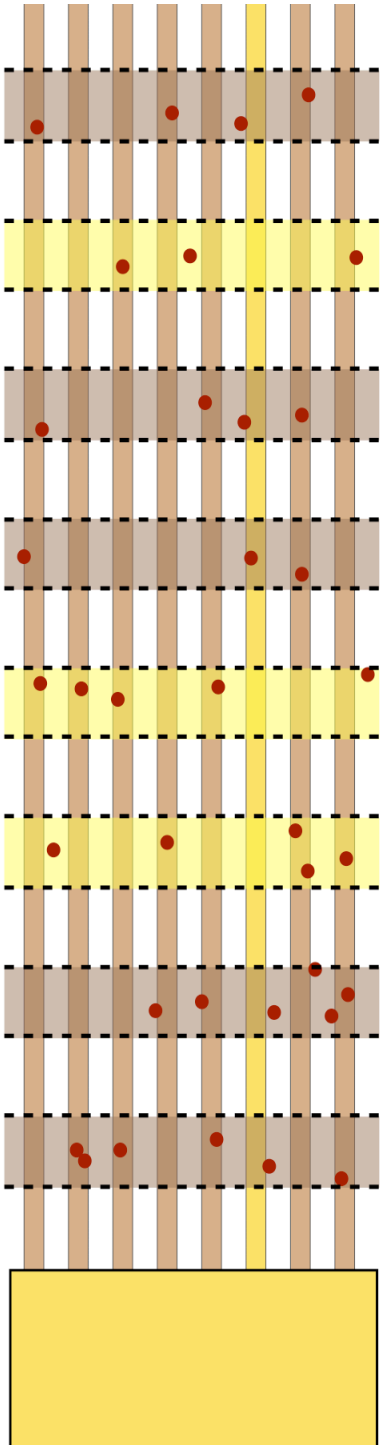


# Nanowire Decoder Assembly

- Several types of decoder have been proposed. They varies in how MWs are coupled to NWs.
- In a **mask-based decoder**, randomly shifted regions of high-K dielectric focus each MW's electric field on only certain NWs.
- In an **encoded-NW decoder**, NWs are grown with a sequence of lightly and heavily doped regions.
- In all cases, decoder assembly is stochastic.

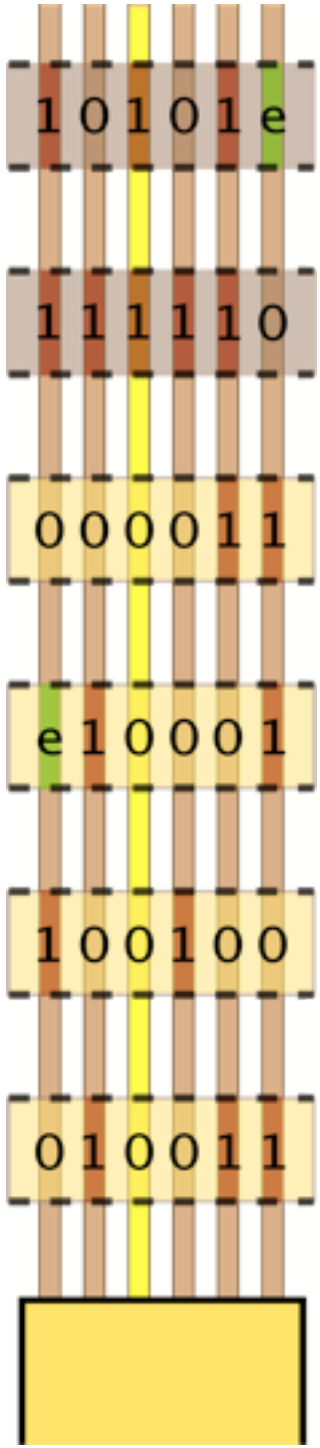
# Codeword Assignment

- NW codewords can model each of the proposed NW decoders.
- When a decoder is manufactured, codewords are randomly assigned to NWs according to some distribution.
- An RCD is any decoder where $c_{i,j}$ are independent identically distributed random variables.



# Decoder Requirements

- Many NWs connected to each OC should be individually addressable.
- A NW is individually addressable if no other codeword implies it.
- One codeword implies another if
- If the number of MWs is sufficiently large, many NWs will be individually addressable with high probability.



# To Review…

- Core-shell nanowires generate codewords which are never misaligned!
- Linear decoding creates high density memories with only two shells!
- More sophisticated decoding permits efficient fault tolerance!