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

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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.
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!