

# 3D Silicon Nanowire Architectures for Neuro-Morphic Computing

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# **Main Goal: Neuro-Morphic Chips with Very High Integration Density**

**Implement neuro-morphic computing systems that mimic the operation of neuronal/synaptic clusters + allow these silicon brain cells to operate concurrently with biological neurons, by exchanging information/signals/stimuli, side-by-side.**

**Exploit ultra-high density silicon nanowire devices**

**Exploit novel device functionality that is above and beyond what CMOS technology can offer**

**Exploit 3D silicon integration technologies at the device level and at the system level**

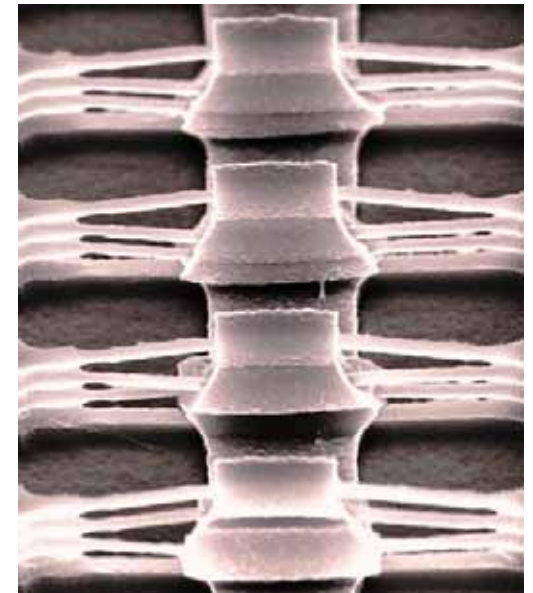
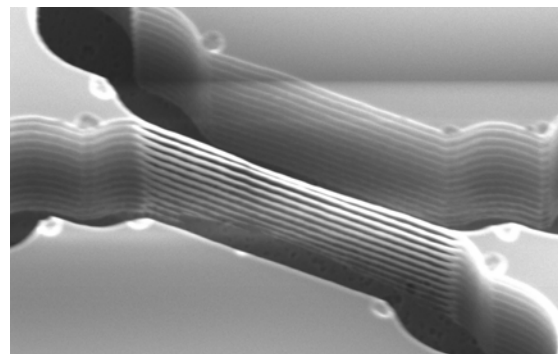
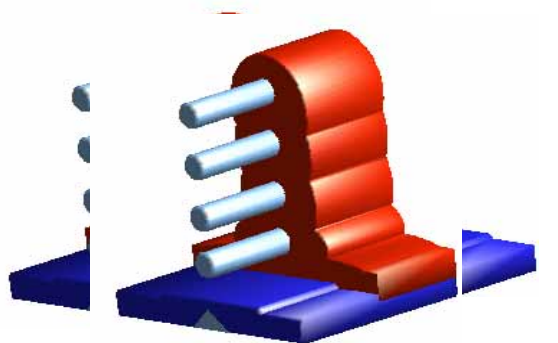
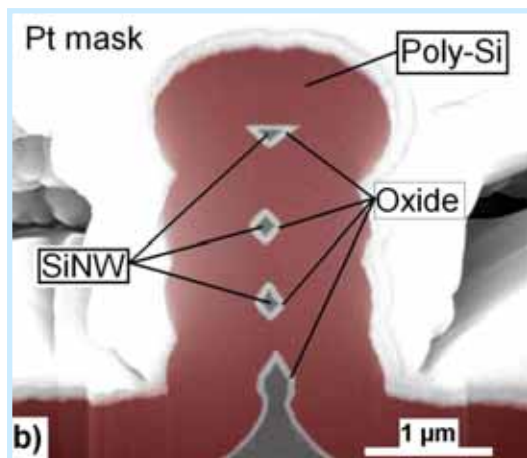
**Exploit novel neuro-electronic interfaces.**

# Motivation: Why Silicon Nanowires ?

Very high integration density / possibility of vertical stacking

Novel device functionality (ambipolarity, memristive effects,...)

Compatible with conventional CMOS technology

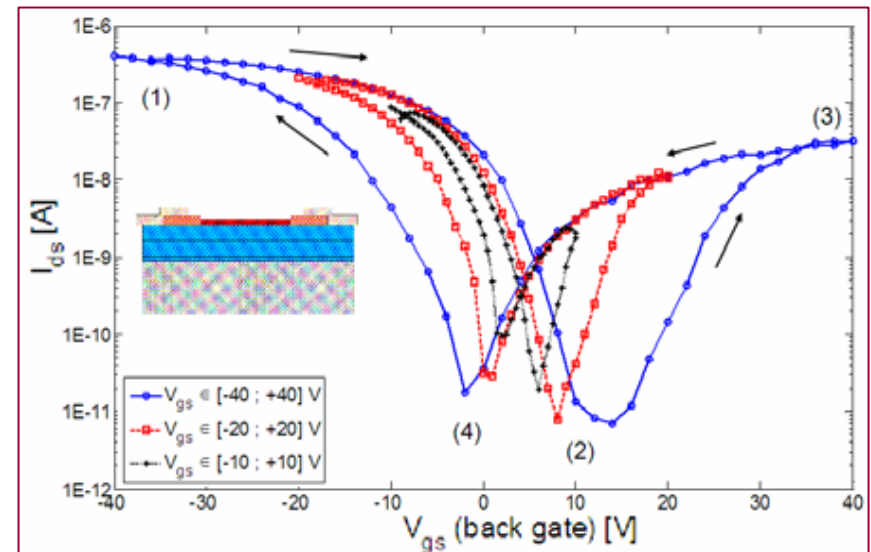
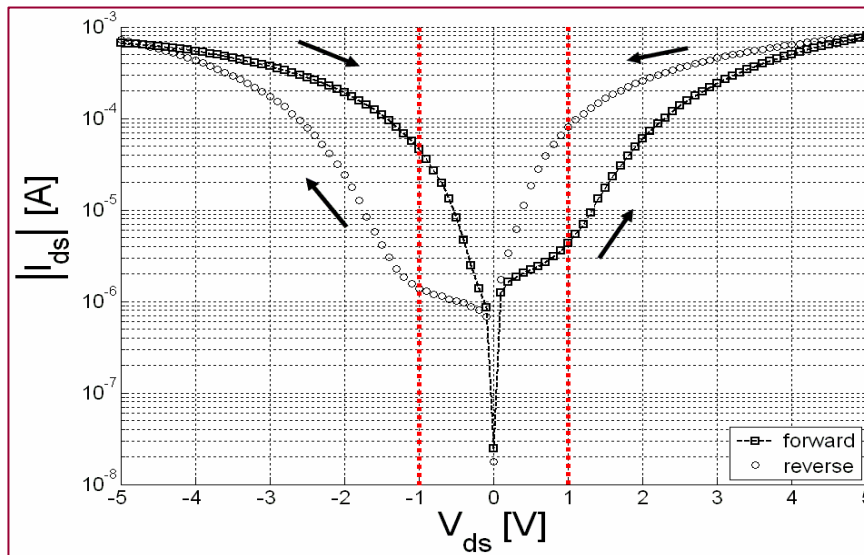


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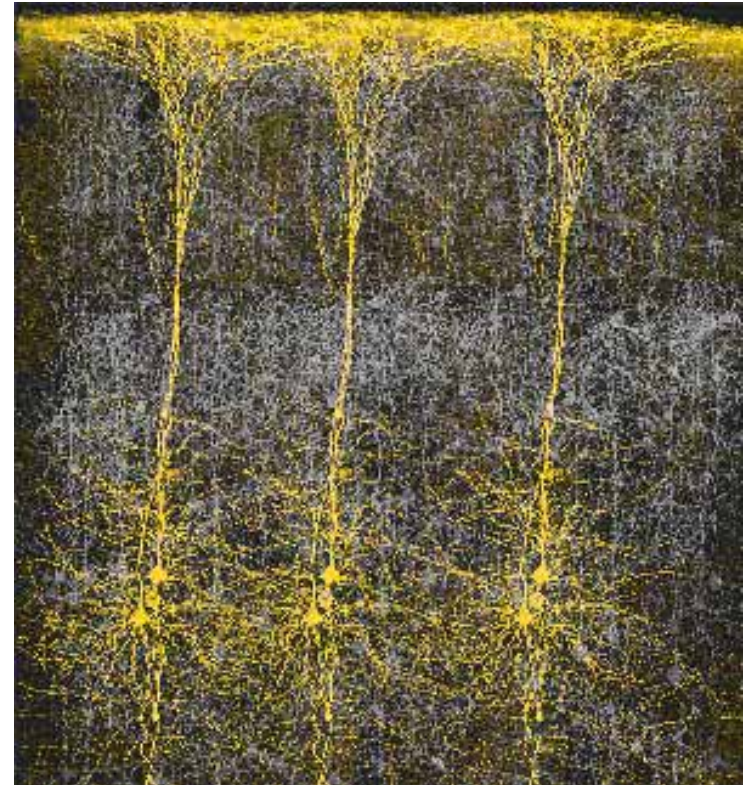
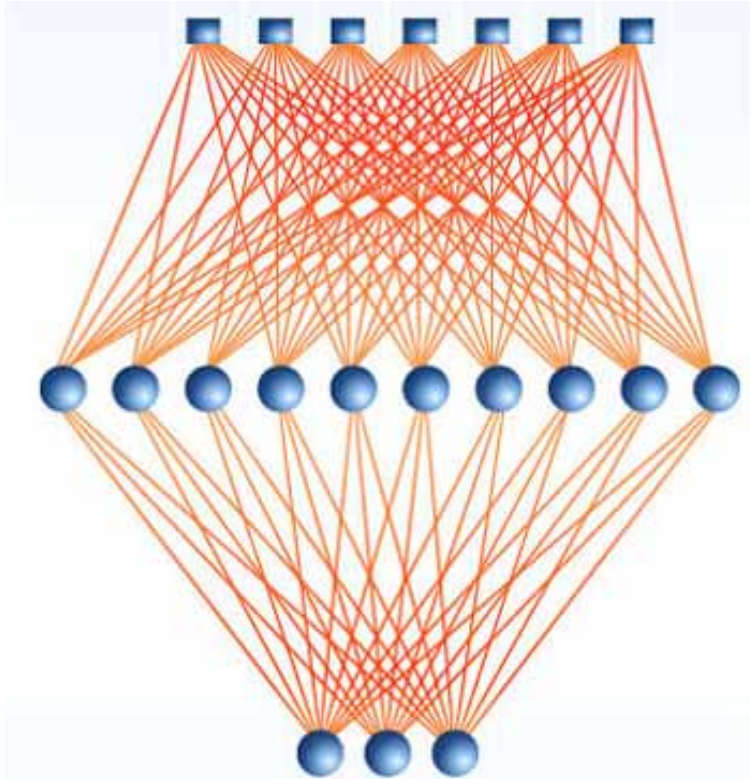


memory / multi-valued logic gates

ambipolar behavior

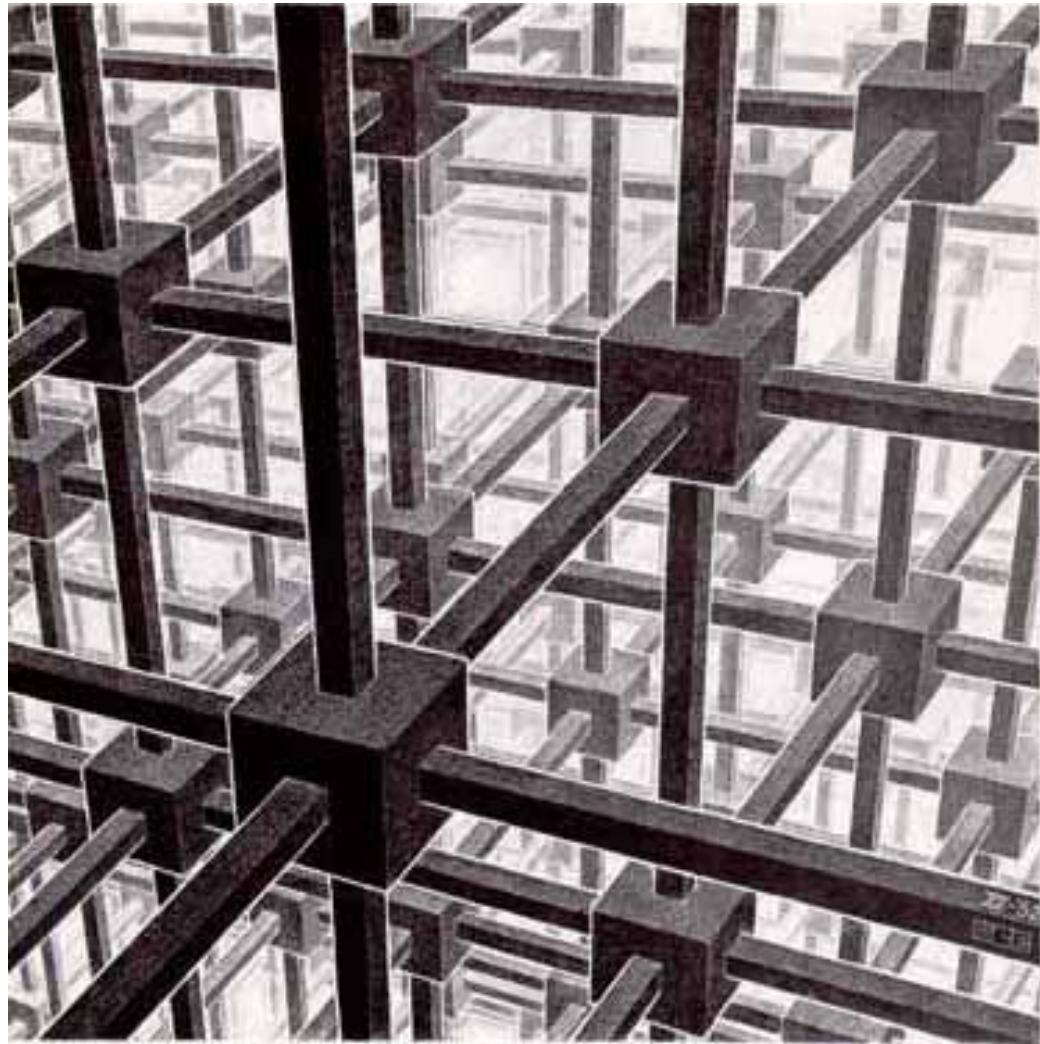
properties not easily achievable by conventional CMOS...

# Highly Interconnected Networks



complex networks where each building block (node, element) is capable of processing large number of inputs and modifying their own behavior...

# Motivation: Why 3D ?



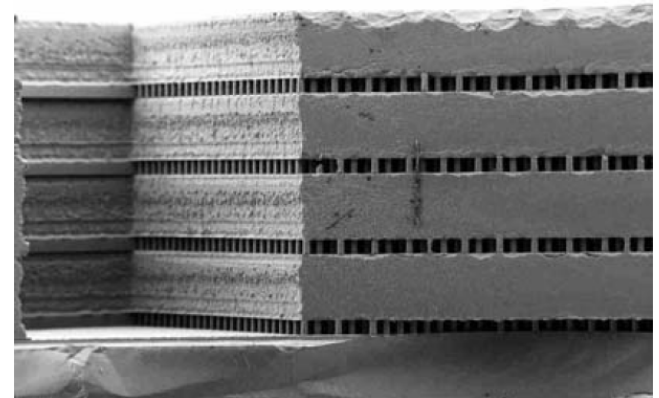
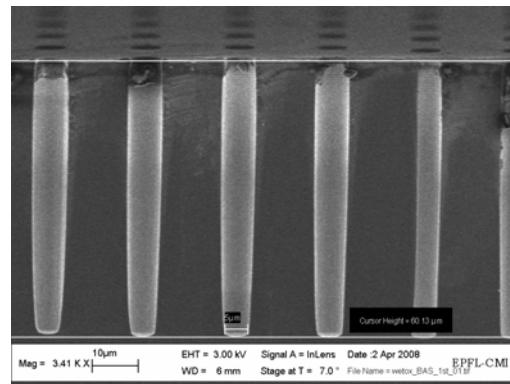
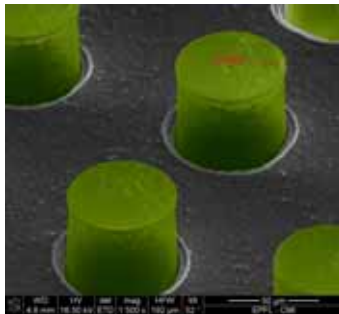
# Motivation: Why 3D ?

Allows very high integration densities that are not achievable with technology scaling alone...

Need to reduce system footprint / total area (form factor)

Need to reduce interconnect lengths (faster operation)

Need to integrate different species of chips (heterogeneous systems integration) – use more exotic/novel technology only for the parts that cannot be built otherwise...



# Main Research Challenges

High-density interconnects ?

Exploiting the 3<sup>rd</sup> dimension ?

Power dissipation ?

Liquid / wet environment ?

Representing / encoding information ?

Coping with uncertainty / variability ?

Neuron-to-digital interfaces ?

# Collaboration

- **Simulating the Human Brain (H. Markram)**
- **Neuromorphic Computation Facility (K. Meier)**

**Centered on**

**ICT (Neuromorphic)**

**Strong links to**

**Life Sciences**

**Material Science**

