

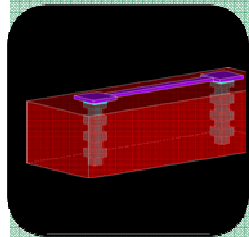
# NanoMech™ non-volatile memory moves toward production

Cor Schepens  
Cavendish Kinetics

# Cavendish Kinetics

Cavendish Kinetics is a semiconductor IP company developing its patented Nanomech™ low-power, high-speed embedded Non-Volatile Memory technology for standard CMOS processes

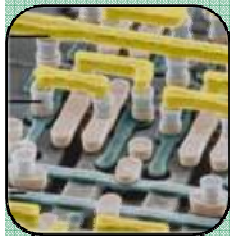
## Core Competencies



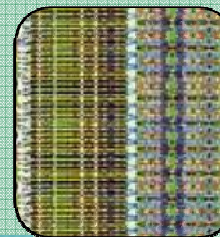
- ❖ Standard CMOS-based MEMS Technology, Device Development, Design & Modeling



- ❖ CMOS Process porting, integration and qualification

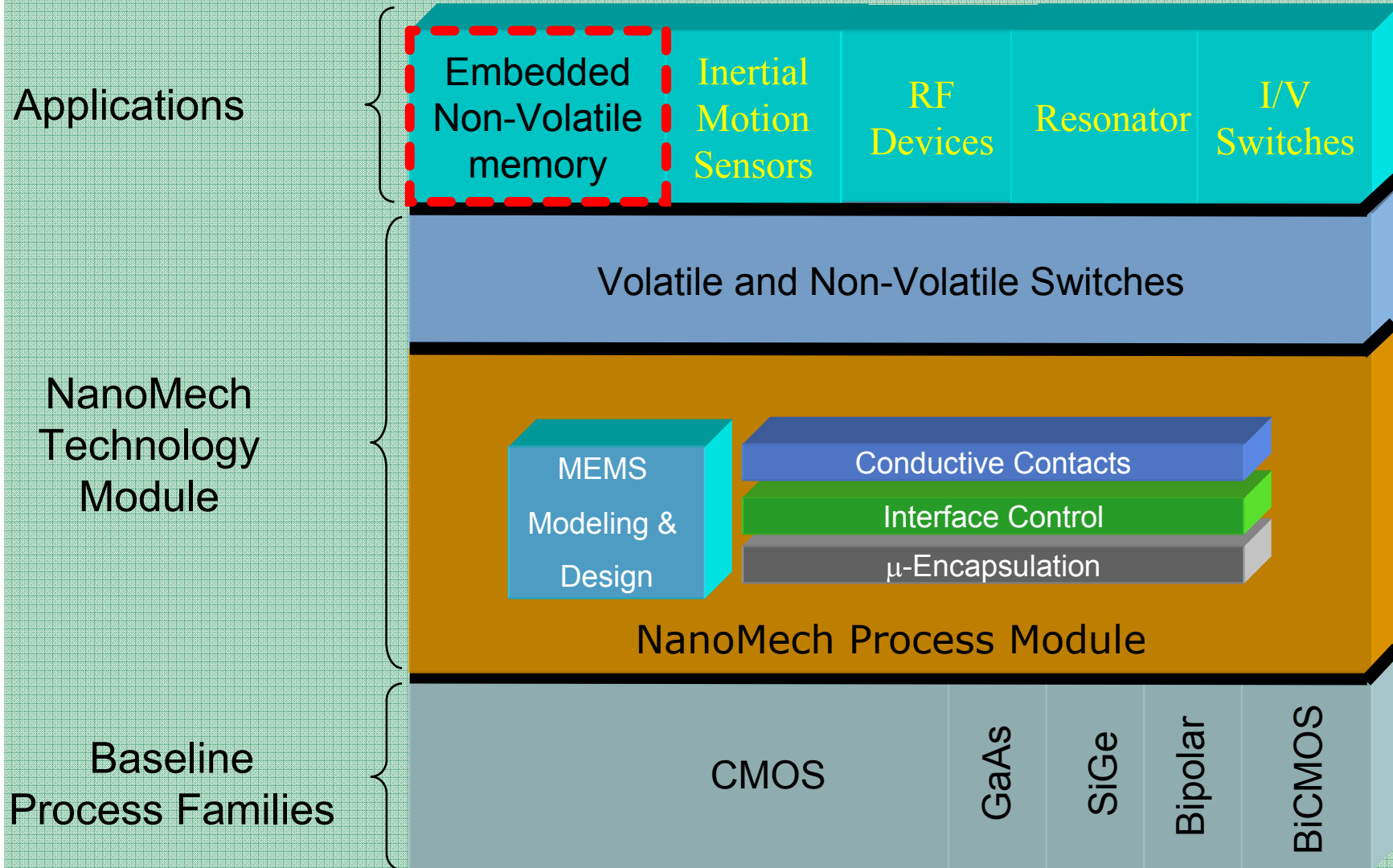


- ❖ (CMOS) Interconnect Process Technology



- ❖ Memory Design, Analog- and Mixed-Signal Design

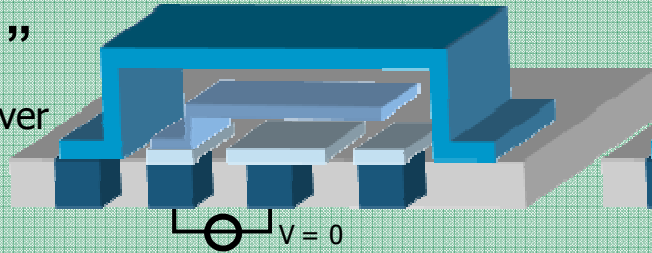
# NanoMech Application Framework



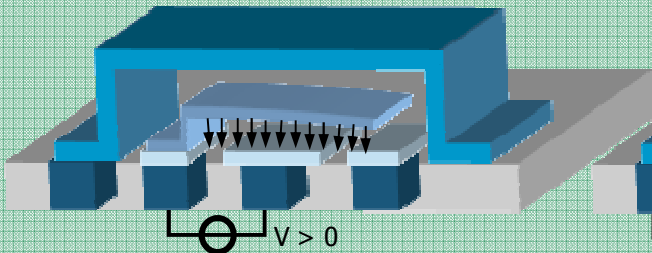
# Nanomech NVM Operating Principle

## Write "1"

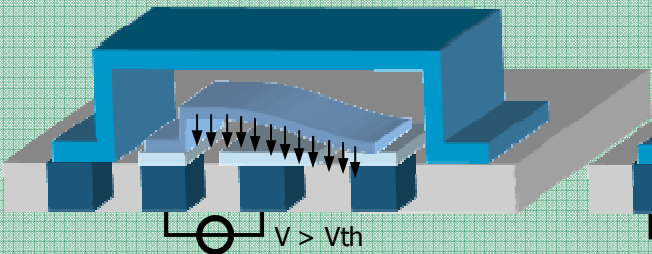
1) Initially cantilever switch is open



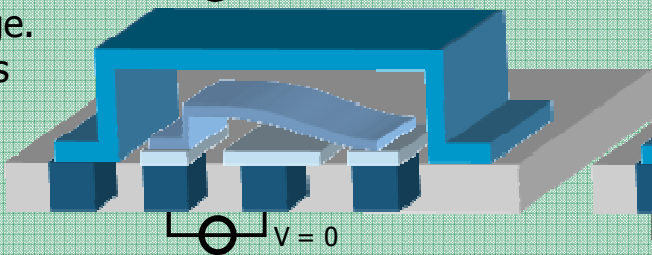
2) Increasing the voltage results in a force on bottom of the switch



3) Above pull-in threshold voltage the switch will close

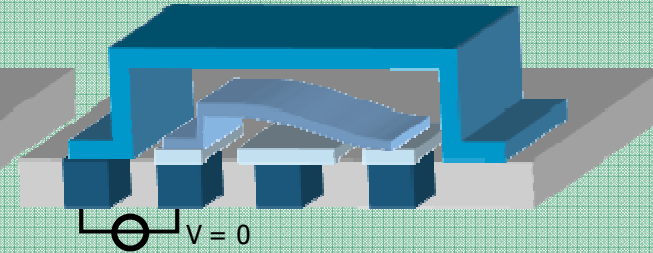


4) Remove voltage. Switch remains closed due to stiction

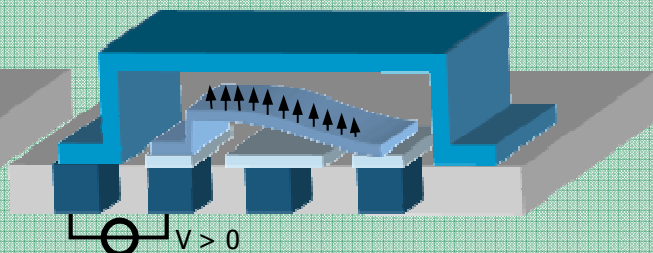


## Write "0"

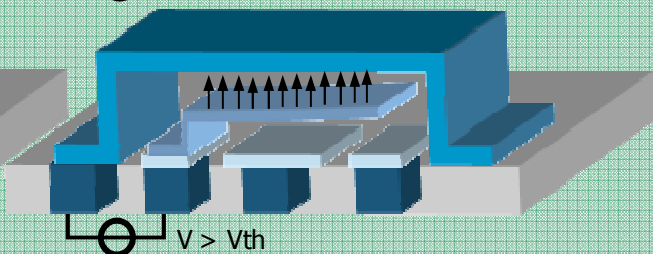
1) Switch is closed



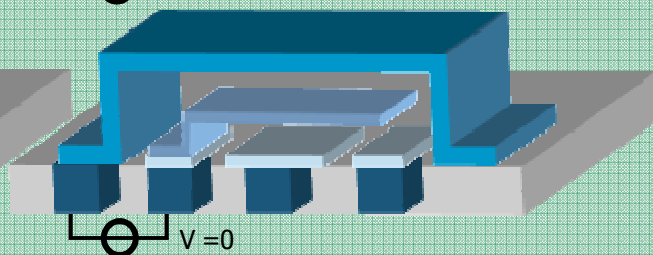
2) Increasing the voltage results in a force on top of the switch



3) Above pull-off threshold voltage the switch will open



4) Remove voltage. Switch remains open



# Existing eNVM Technical Challenges

- Conventional embedded NVM technology is running into a number of significant hurdles:
  - **Scaling**
    - Conventional NVM scaling does not track process technology scaling
  - **Voltage**
    - Continued scaling of native voltages on chip level not supported by conventional NVM
  - **Power**
    - Power consumption and leakage current now a significant problem for conventional NVM
  - **Reliability & Life time**
    - Scaling of process technology with conventional NVM significantly decreases reliability and lifetime
  - **IP Compatibility**
    - Conventional NVM is difficult to combine with other IP without significant re-work

# Nanomech NVM Performance Advantages

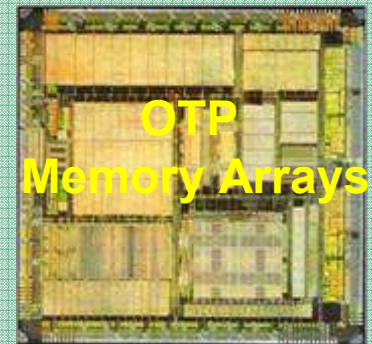
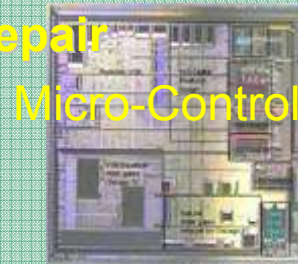
- Nanomech Non-Volatile Memory Product offers:
  - 100x to 200x write performance improvement ( $\ll 500\text{ns}$ )
  - 50x to 100x power reduction for write operations (Electrostatic)
  - Program at native voltage (Easily scalable)
  - Equivalent or reduced effective footprint for the bit cell
  - High endurance ( $\gg 1\text{M}$  cycles)
  - Data retention ( $>10$  years) across full temperature range
  - Read and write operations to  $200^\circ\text{C}$  and above
  - Secure
  - Radiation hard – No electron storage
  - Significantly lower cost
- Easy Integration
  - Complete compatibility with other embedded process options
  - Zero impact on existing FEOL technology and IP portfolio
  - Easy porting due to BEOL implementation
  - No new equipment or materials required
  - No special handling required with no impact to test & assembly flow
  - Scalable to 45nm and beyond

# Applications Benefiting From Nanomech

- New Markets



- Existing Markets



# Research to Realisation Facts

- Idea originates from Cavendish Labs (Uni of Cambridge)
  - Prototype build at Cavendish Labs
  - Too large and from different materials
- Established Cavendish Kinetics B.V. in 2001
  - Received \$6M funding
  - Focus on FUSE (one time programmable device)
  - Process work at IMS Stuttgart
- Established Cavendish Kinetics Inc. in 2006
  - Received \$15M funding
  - Focus on eNVM (multi-tim programmable device)
  - Moved process work to SVTC in San Jose (24/7 fab)
  - Higher throughput, better quality
- Strategic customer partnership with NSC in 2007
  - Focus on process transfer and qualification at production fab

# Research to Realisation Goals

- Product needs to be very low cost
  - Standard CMOS materials and equipment
  - Keep process simple
- Millions of devices on one chip
  - Requires yield similar to CMOS transistor
  - Reproducible across chip, wafer and lot
  - ‘Memory redundancy’ for large memories
- Involve customer early on
  - Get feedback on specifications
  - Learn about their process development methodologies
- From MEMS to NEMS
  - Go where no-one went before → cut your own path through the jungle
    - Beyond the scope of simulation tools
  - Time and money intensive

# Conclusion

- The large market potential of the Product justifies a large development project
- Nanomech is a new MEMS technology with ambitious challenges:
  - From MEMS to NEMS
  - Millions of devices on one chip versus one MEMS device per chip
  - High requirements for reliability and reproducibility
- Steady progress on path to product success

# Acknowledgements

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  - Dutch Ministry of Economic Affairs in the framework of the Point One project:  
MEMSLand [[www.memsland.nl](http://www.memsland.nl)]
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