

NEM Switch devices and applications

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Business Interest Group Webinar

4 Oct 2023

NEM Switches- sense, compute and communicate in extreme environments!



Microchip Technology in Europe

- Microchip Caldicot
 - Expertise in sized reducing complex electronics
 - SMT, CoB, embedded die in PCB
 - Electronic packaging for harsh environments
- Microchip Aerospace and Defence
 - Experts in Radiation qualified chips: FPGAs, ASICs, NVM

**Microchip
Advanced
Packaging**

Microchip ADG



Aviation and Defense



Microchip Technology Inc.

Microchip
Technology



Corporation



microchip.com

Microchip Technology Incorporated is a publicly listed American corporation that manufactures microcontroller, mixed-signal, analog, and Flash-IP integrated circuits. [Wikipedia](#)

Stock price: 0K19 (LON) US\$81.86 0.00 (0.00%)

16 Nov, 19:03 GMT - Disclaimer

Headquarters: Chandler, Arizona, United States

Subsidiaries: Microsemi, Micrel, MORE

CEO: Ganesh Moorthy (Mar 2021–)

Revenue: 8.439 billion USD (2023)

Number of employees: c. 22,600 (2023)

Founded: 1989



- Microchip business has been built on Microcontrollers
- Expanding to be a worldwide electronic device manufacturer



i-EDGE

EDGE COMPUTING FOR
EXTREME ENVIRONMENTS

Confidential information

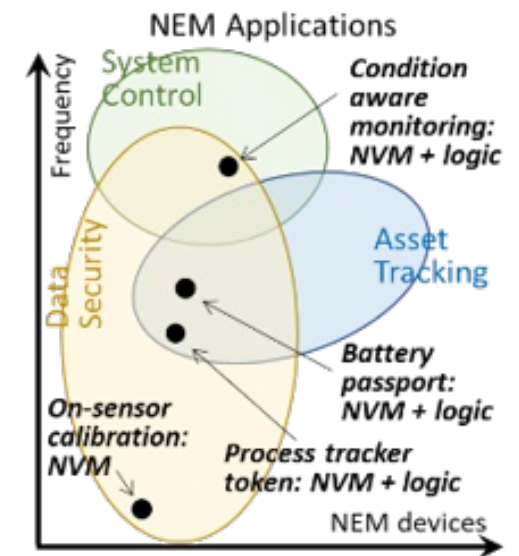
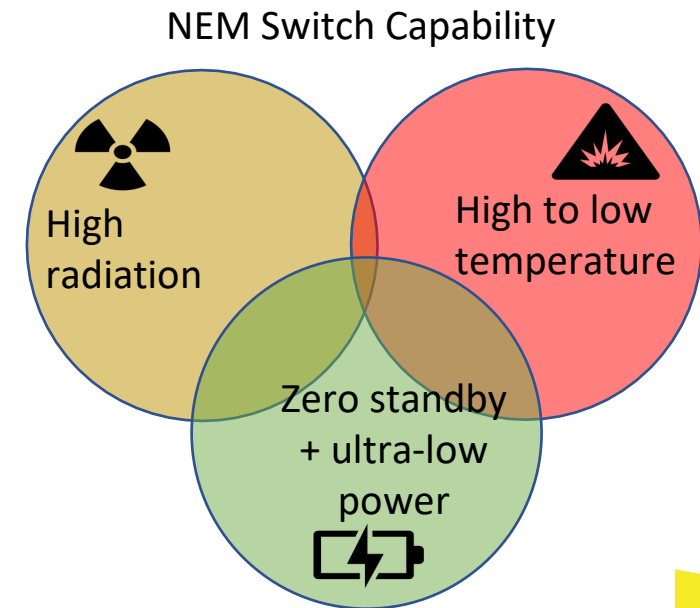
NEM Switches- sense, compute and communicate in extreme environments!

Introduction to the i-Edge Project business aims

- The over-arching concept of i-Edge is to prepare a new business
- The i-EDGE project plan aims for this to be achieved by:
 - 1) Taking NEM Switch technology from TRL2 to TRL6
 - 2) Planning and implementing a manufacturing process.. “lab to fab”
 - 3) Finding applications and developing products
 - 4) Interaction with our Business Interest Group (BIG)

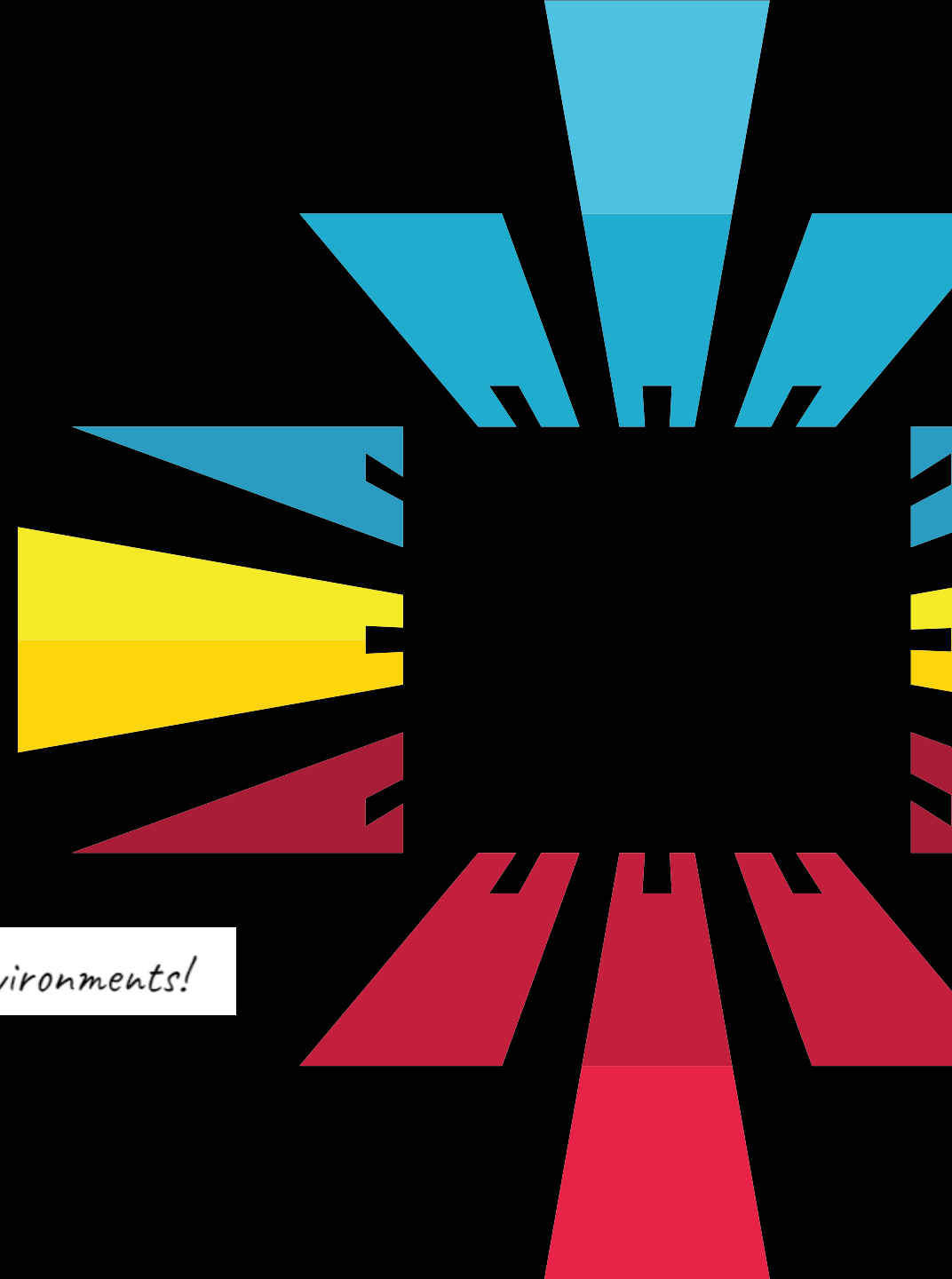
Applications field

- Our products must fully use NEM Switch's three advantages
- Best applications will lie in overlapping area of this Venn diagram
- This has guided our market research
- At TRL2/3, we are at Kilby and Noyce stage of IC development
 - Very low oscillator frequencies, life of 10^8 cycles
 - Low level of integration
 - We aim for own our "Moore's law effect"



NEM Switch Technology applications

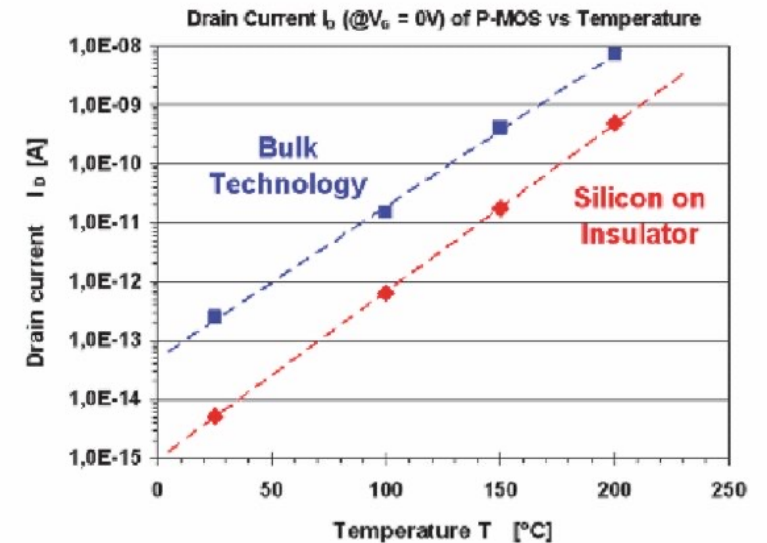
NEM Switches- sense, compute and communicate in extreme environments!



Why might NEMS temperature measurement devices win?

- As temperature increases, semiconductor drain currents increase.
- Batteries become dangerous and unusable above 150C
- Low power from unconventional source have to be used to supply power.
 - Capacitor banks
 - Mechanical energy harvesting
 - RF energy harvesting
 - Thermal energy harvesting

Drain current of a type of CMOS FET versus temperature



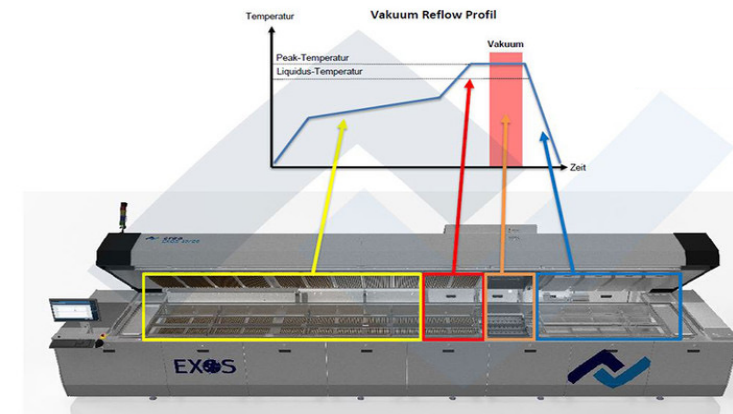
Potential temperature measurement applications

- 1) Temperature profile measurement of belt ovens
 - Where the NEM Switch temperature measurement device is transported through the oven on its belt. NEMS device is read on exit.
- 2) Realtime measurement batch oven measurement
 - RFID transponder used to communicate with NEMS device(s) in the oven
- 3) Rugged asset tracking
 - NEMS device compliments / integrated with CMOS to retain data or function at high temperatures.



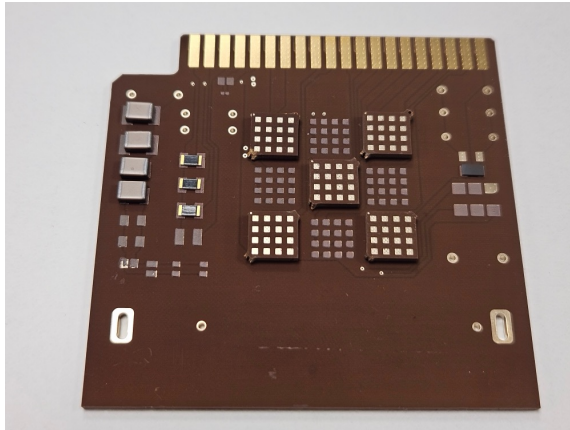
1) Temperature profile measurement of belt ovens with NEMS

Complex task to take a thermal profile on a belt oven

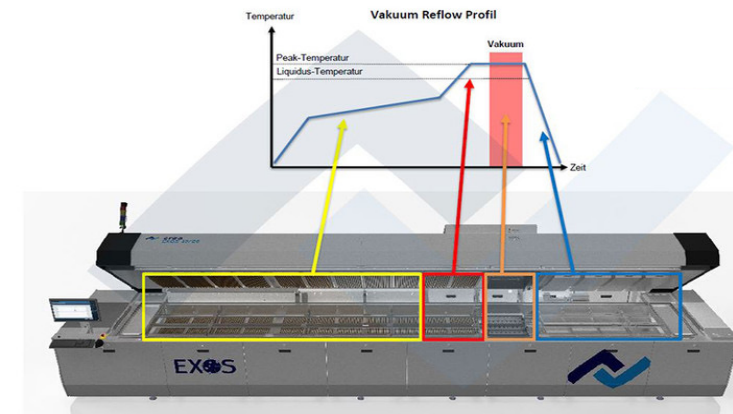


1) Temperature profile measurement of belt ovens with NEMS

- Complex task to take a thermal profile
- No heat shield for NEMS, it can be mounted on a PCB and emerge cold
 - no gloves, leads etc... allowing frequent measurement and better process control



Example of Microchip high temperature assembly technology



Realtime batch oven measurement

- Meater – meat thermometer

- Max temp 100C
 - (Protected by the meat)
- Bluetooth
- Diameter 7mm
- Probe weight 200gms



- NEMS

- Max temp 325C – active circuitry can sit anywhere
- RFID
- Probe diameter – needle, magnetic, screwed down
- Probe weight – low (with a light flexible cable to external NEMS reader)

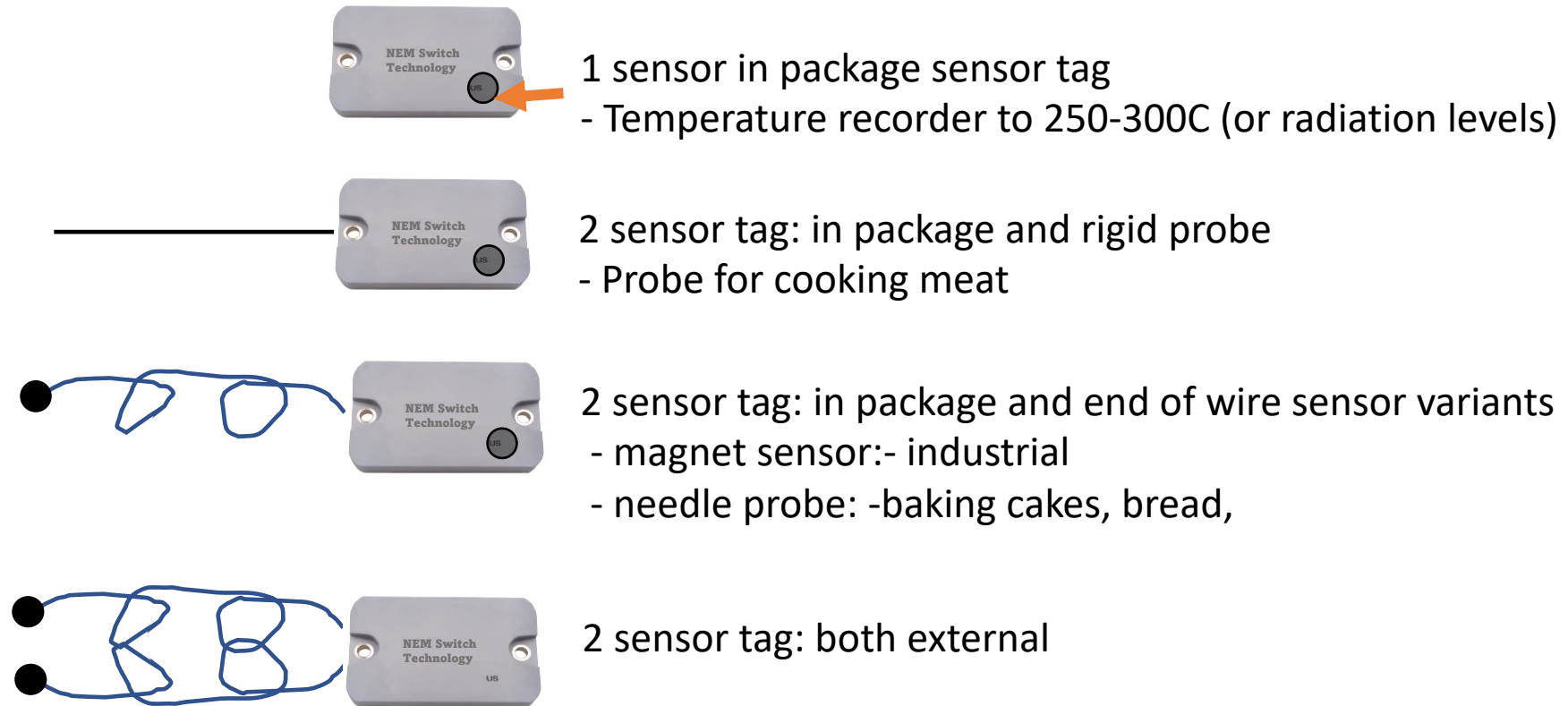
 Simple
Insert the probe in the meat, follow the app instructions.

 Wireless
100% wireless for hassle-free cooking.

 Perfect Results
The 'Guided Cook System' guarantees perfect and consistent results.



Packaging options – sensor configurations



3) Rugged manufacturing flow asset tracking

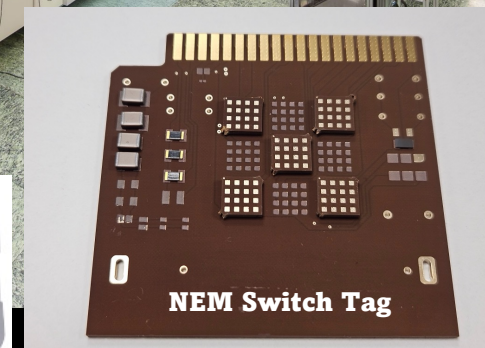


- Many manufacturing flows contain a critical high temp step
 - eg a solder reflow, hot chemical baths, glue cures, drying



- Current RFID tag specifications
 - Operational -40°C to $+85^{\circ}\text{C}$, *Survival -40°C to $+250^{\circ}\text{C}$ *
 - RFID

- NEM Switch tag specification
 - Operational -40°C to 250°C plastic case, 325°C ceramic case
 - On board sensors – shock, humidity, temperature
 - Tracking **with process monitoring**



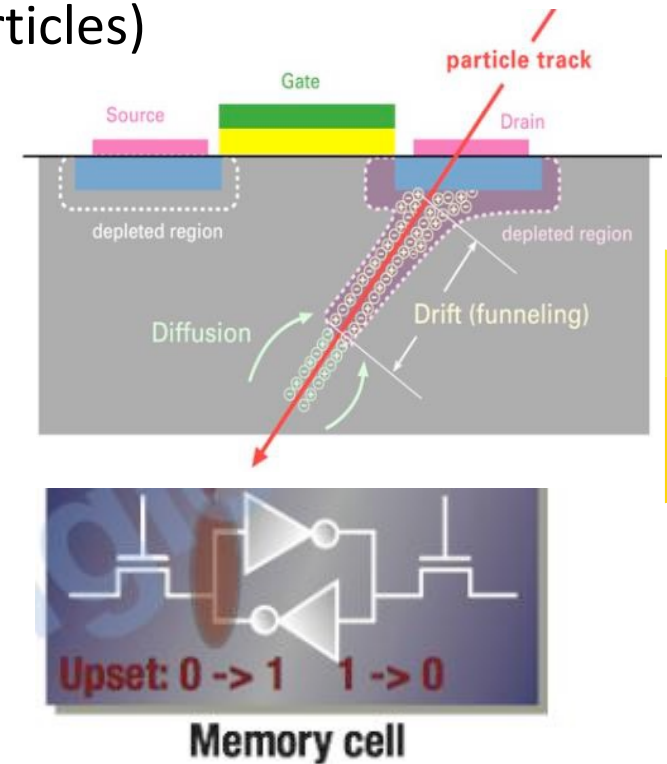
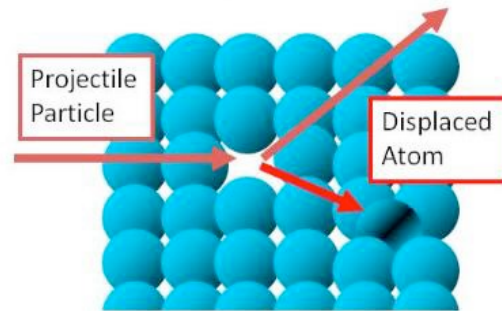
Cryo asset tracking for BioBanks



- Barcodes are typically used in BioBanks (medical samples stored at -40 to -70°C), but:
 - The barcode label is often frosted and has to be extracted and wiped clean to be read.
 - This warms the sample and potentially degrades its viability.
- A combination of NEMS RFID and barcode would allow cold temperature reading and double means of identification.
- NEM Switches should not suffer from the technical problems of cold for CMOS:
 - Such as band gap narrowing (increased charge carrier), subthreshold (off state) leakage and gate leakage.
 - CMOS RFID: non functionality, or increased power consumption leading to a decrease in RFID tag read range?

NEMS overlay complimenting CMOS in radiation?

- CMOS is instantly affected by sudden upset event from energetic particles
 - Most times, a reset or reboot restores the system (lower energy particles)
 - Sometimes, a FET is permanently damaged (higher energy)
- CMOS is gradually degraded by all radiation
 - This calibrated by a Total Ion Dose



- NEM Switches do not suffer these problems

Potential radiation applications

- 1) Real time radiation level mapping
 - Bringing together multiple sensors for radiotherapy, industrial or nuclear industry
- 2) Radioactive asset tracking and monitoring
- 2) Electronic components for $>10\text{MRad}$, $>100\text{KGys}$
 - FPGA, NVM, ADC, Power control
 - Either as all NEMS or NEMS on CMOS



NEMS overlay complimenting CMOS in harsh environments

- **At Temperature**

- Most activities will be at room temperature or have periods at room temperature
 - eg the case of 3) rugged asset tracking
- CMOS circuits lose all data..... but are not destroyed by temperature.
 - Ie function again when near room temperature
- NEMS can continue processing, collect data and / or retain data for when CMOS returns

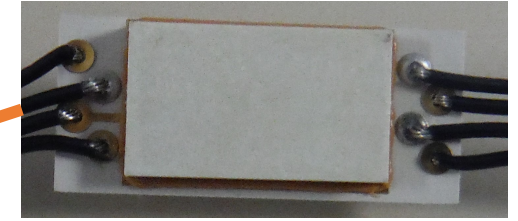
- **In high radiation levels**

- NEMS can provide a memory for a reboot after a sudden upset event from a charged particle.
- **NEMS can compliment and support CMOS**

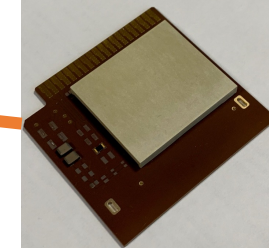
Packaging options



a) Plastic packaging

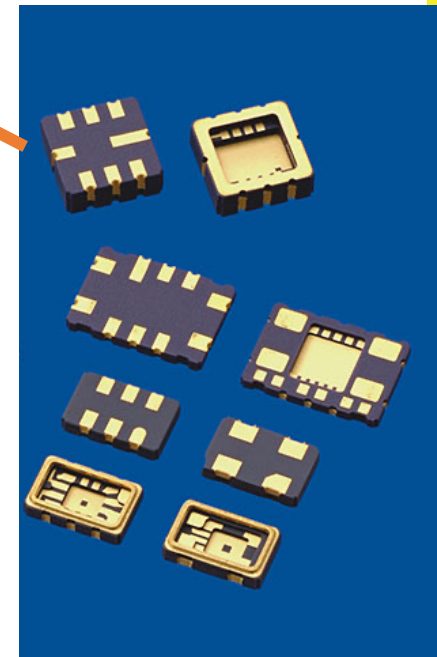


b) Plastic packaging



- Previous plastic packaging tests
 - Packages a) and b) survived 250C and thermal cycling -20 to 250C
 - Lower cost option
- Ceramic packaging
 - Venus lander packaging is using ceramic and surviving 465C
 - 325C will be our test condition in ZeroAMP
 - Higher cost option

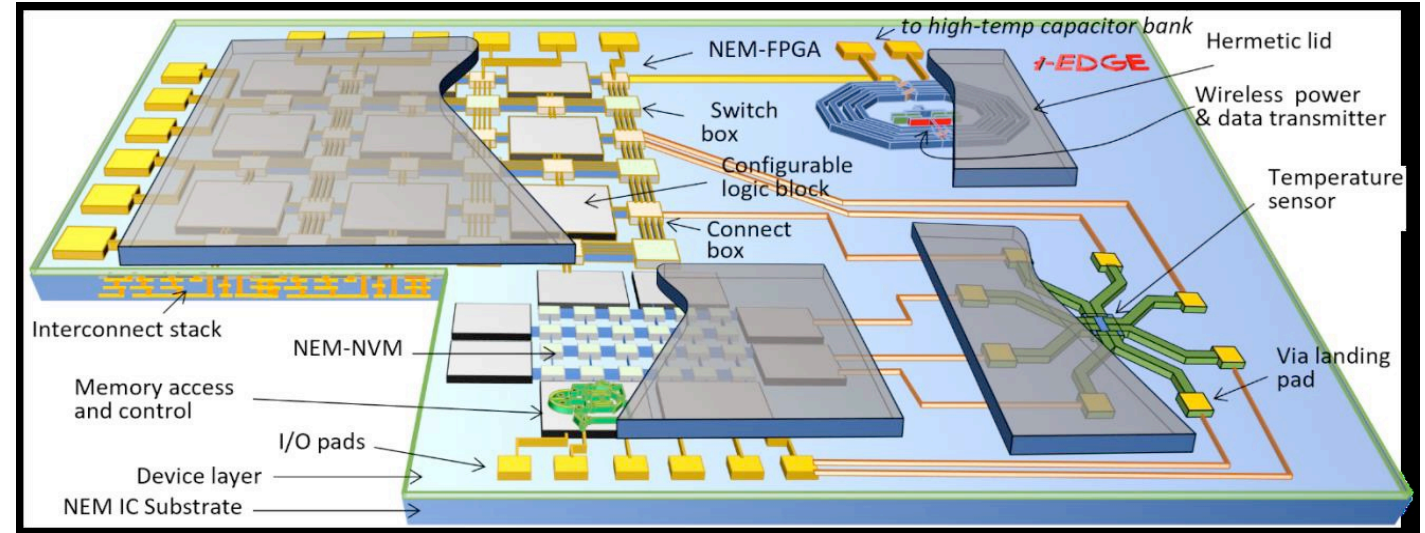
c) Ceramic packaging



Our planned chips

Single chip risRAT

- robust intelligent sensing RFID Asset Tracker :
“sensing where you are, in any environment”



- We are planning to have a multi project die for the next wafer run project
 - A sensing, computing and communicating platform die
 - Individual components: FPGA, NVM, ADC etc.

Conclusion

- NEM Switch Technology has unique properties that lend itself to the applications that have been described
- We have discussed packaging
 - We have three styles of packaging for the applications already mentioned
 - We have described a platform chip and component chips
- We hope to discuss the technical details of all this in more depth under NDA

NEM Switches- sense, compute and communicate in extreme environments!

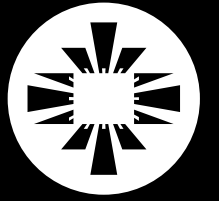
NEMS Switch Technology

END





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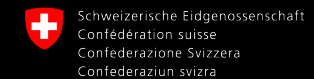
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