Industry Day Theme # Clean Energy For Sustainable Environment

IIT DELHI INDUSTRY DAY 2019

Microsystems Technologies for Powering the 'Internet of Things-IoT'

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Abstract

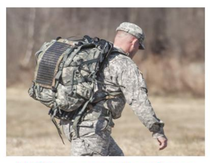
With 'Energy' identified as one of the most significant challenges facing the society, our aim is to deliver novel solutions in efficient energy management for next generation of low-power electronics. Our activities are focused on enabling self-powered, sensor-driven condition monitoring applications leading to 'smart and sustainable environment', where the required power will be derived from the ambience and the harvested power will be delivered wirelessly.

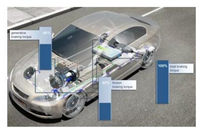
Introduction

Vision: Trillion sensors (TSensors) eco-system by 2035

- Spatially distributed trillions of tiny Wireless Sensors will exchange information among each other.
- Goal: Smart, Sustainable Environment -
  - Energy efficiency
  - Resource efficiency


Environmental Monitoring


Military applications

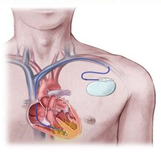

Interactive and Control

Self-powered Wireless Sensing

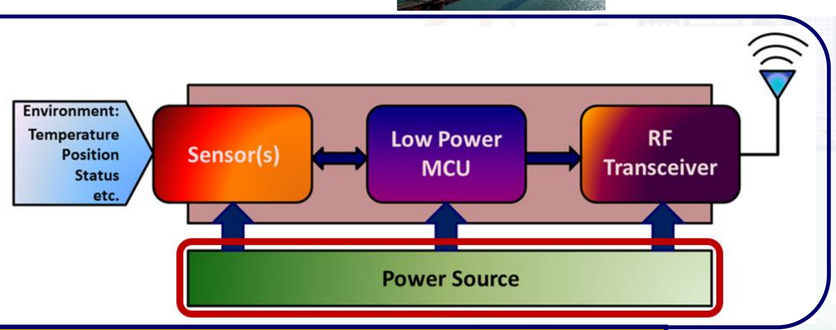
Surveillance

Structural Monitoring

Medical remote sensing



Anatomy of an wireless sensing device within Internet of Things



Can we afford to have trillion batteries?

We are aiming to develop novel energy solutions for perpetually powering the low-power sensors through innovations in micro-systems technologies.

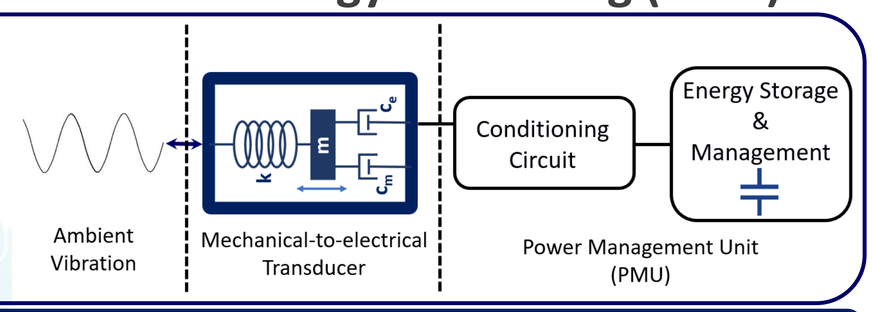
Our Group's Expertize

MEMS/Micro-systems Engineering

Material Integration	Device Development	Interface Electronics
• Device Compatible • Magnetic/PZT/ME • Intelligent Integration Schemes	• Multi-physics simulation and analysis • Micro-fabrication • MEMS device characterizations	• Focused on application • Device specific • Complete system integration

Ambient Mechanical Energy Harvesting (MEH)

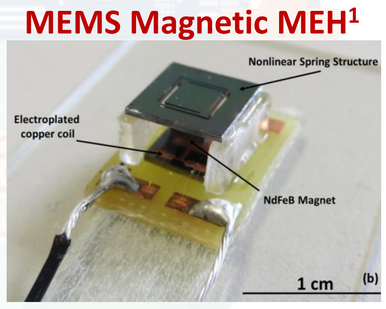
Block-diagram of MEH System



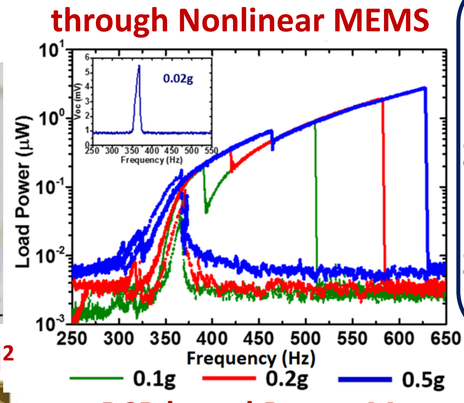
Target Applications:
1. Industrial monitoring, 2. Building monitoring, 3. Body-worn devices.

Solutions:

MEMS Magnetic MEH[1]

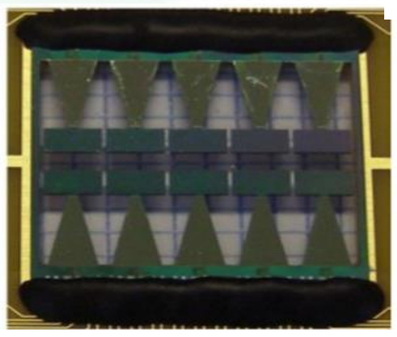


Wideband operation through Nonlinear MEMS

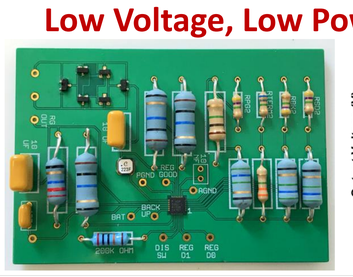


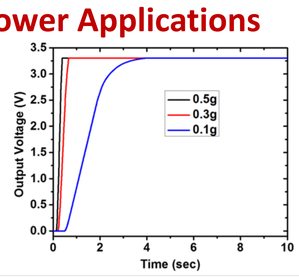
Key outputs:
1. ~100 μW at 0.5g
2. Device volume 0.1 cm^3
3. ~100 Hz wide bandwidth

MEMS Piezoelectric MEH[2]



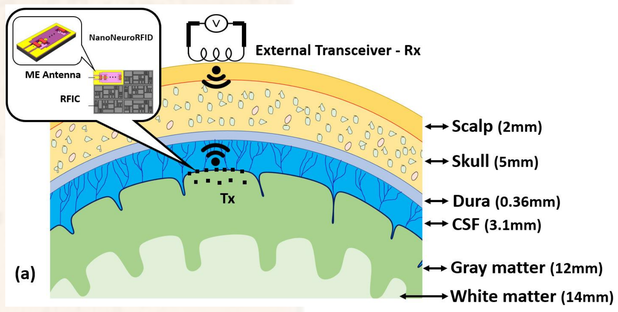
PCB based Power Management Circuit for Low Voltage, Low Power Applications

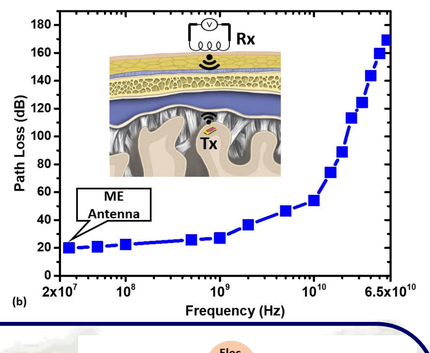




Wireless Power Transfer (WPT) for Implantable Devices

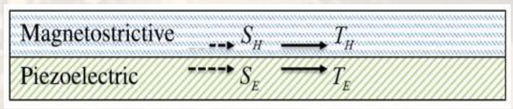
Key Challenge: Antenna size miniaturization[3]. Restriction due to EM wave resonance.

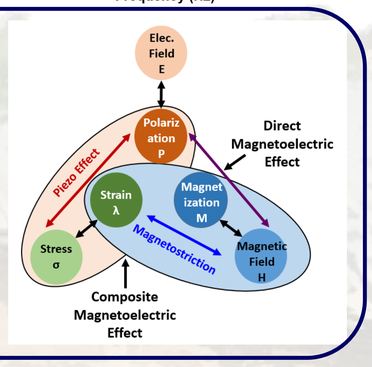


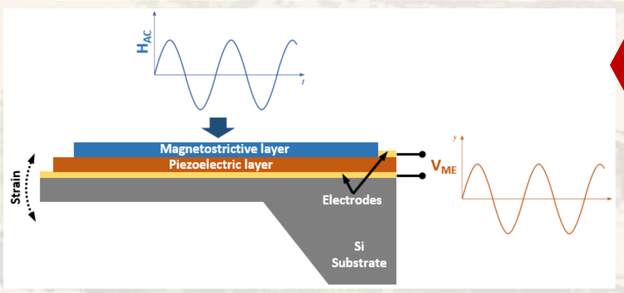


Composite Magnetoelectric (ME) Effect:

- Product property
- Suitable for room-temperature applications
- Passive Nature – little to no power consumption







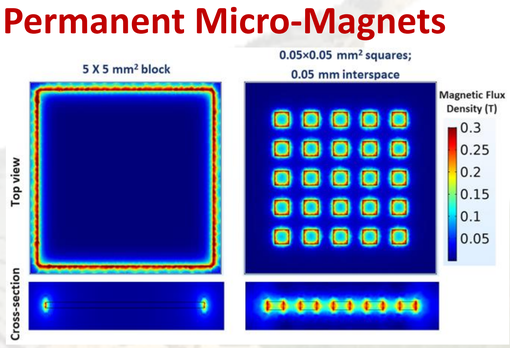
Conceptual diagram of ME Transducer for WPT Applications

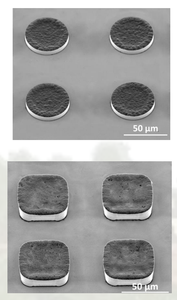
Use of acoustic resonance reduces the device dimensions to MEMS/NEMS scale.

Zero-Power Actuation in Microfluidics

Enabled by Permanent Micro-Magnets

- **Contactless actuation – no on-chip power requirement**
- **Remote control of nano-particles – cell manipulation, drug trapping, localised pressure application**
- **Room temperature operation, CMOS compatible.**





High energy product CoPtP micro-magnets developed using CMOS compatible processes[5]

References

[1] D. Mallick et al., IEEE JMEMS, 26(1): 273-282 (2017).
[2] N. Jackson et al., Microsystems Technologies, 20(4): 671-680 (2014).
[3] M. Zaeimbashi et al., IEEE J ELECTROMAGNETICS, RF, AND MICROWAVES IN MEDICINE AND BIOLOGY, 3(3), 206-215 (2019).
[4] D. Mallick et al, Phys. Rev. Lett., 119:197701 (2016).
[5] D. Mallick et. al., Journal of applied Physics 125, 023902 (2019).
[6] N. Beigh, P. S. Azad, P. Parkash, D. Mallick, PowerMEMS 2019, Krakow, Poland, December 2019.

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