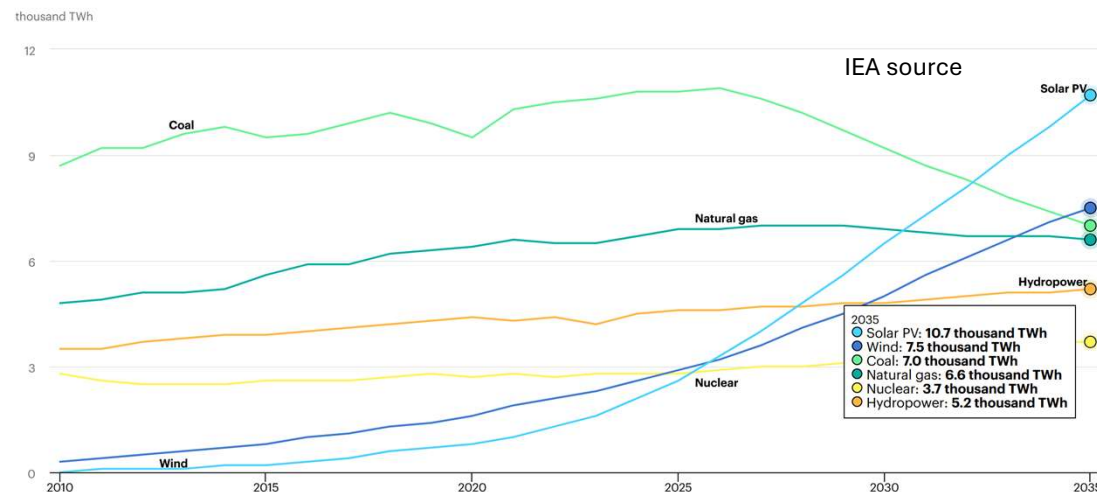


Energy harvesting for sustainable remote sensing

Daniele Davino – Università del Sannio

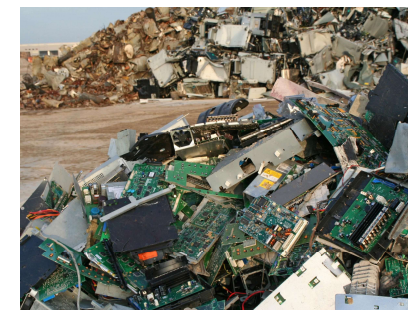
The need for energy is increasing!

- There is a larger and larger need of energy («green» or not...).
- Usually, large plants produce/convert MW-TW ranges to be distributed (HV lines) and used (MV and LV lines) in kW-MW ranges.
- Other needs are coming out...



Sustainability means... less use of raw materials

- Electric lines cannot reach every remote place!
- Technological wastes? Where? When? Why?
- Batteries are a solution for small users; what about replacing and recycling them?



*Change
before you
have to!*

Internet of Things (IoT) & Smart cities: new needs

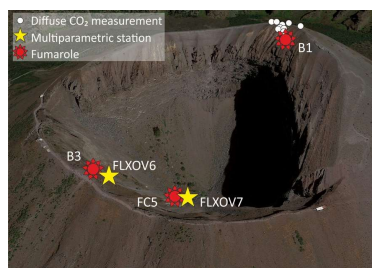
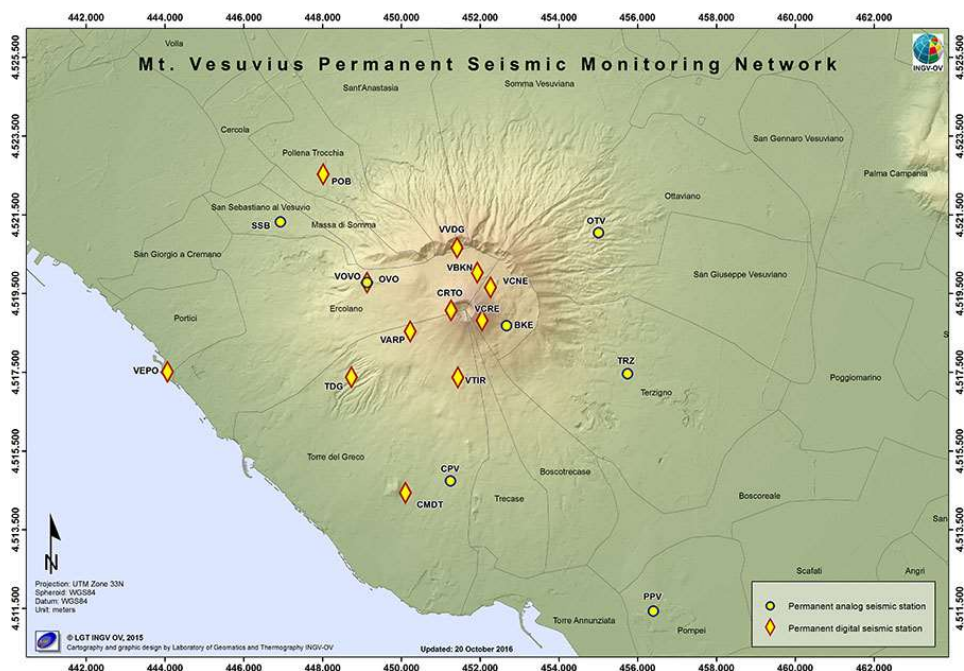
IoT & smart cities demand wireless network sensors that are a completely different paradigm

- Have low powers needs (uW to mW);
- Spread over a (large) area;
- Often, the more rural/remote the location, the more useful they are!



IoT example: monitoring of Vesuvius vulcan

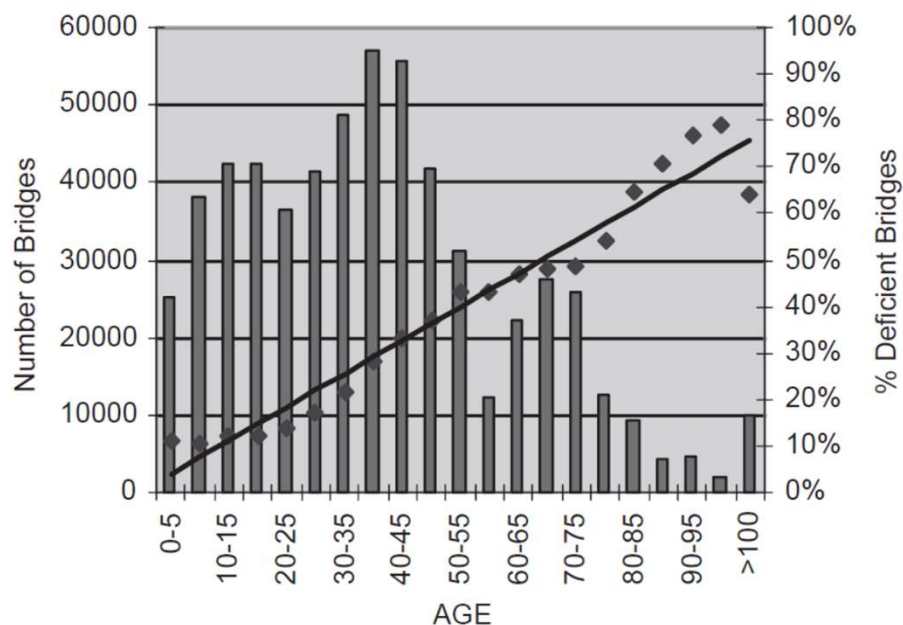
- Vesuvius is probably the best-monitored vulcan because of the large amount of population living in the surroundings!



Source: <https://www.ov.ingv.it/index.php/monitoraggio-vesuvio>

IoT example: Structural Health Monitoring (SHM)

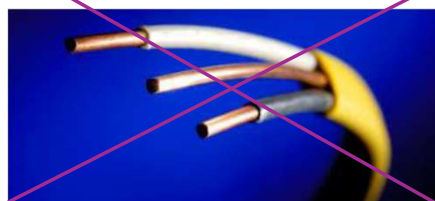
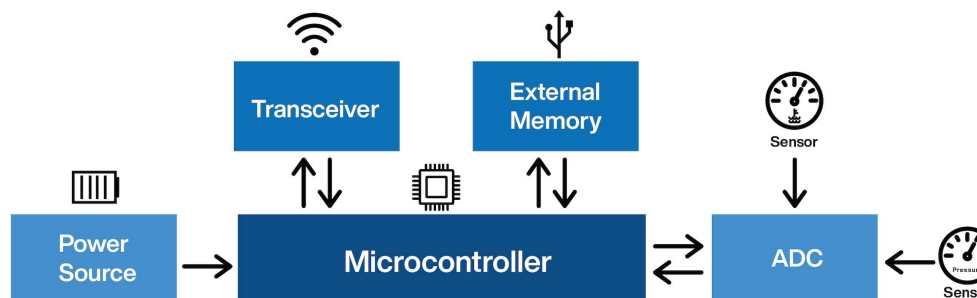
- Because of aged structures, there is an increasing demand of «Structural Health Monitoring» for bridges/viaduct



Source: LWIN, M Myint The important roles of bridge maintenance and management on transportation safety and efficiency In Advances in Bridge Maintenance, Safety Management, and Life Cycle Performance, 16 19 July 2006 Porto, Portugal IABMAS' 06 CRC Press, 2015 p 47

How is it made a sensor node?

- **Sensors**
(accelerometer, gyroscope, humidity, temperature, etc);
- **CPU & data storage;**
- **Wireless data transmitter** (GSM, Wifi, LoRa, etc);
- **Electric power source**
- **Energy source**



Energy harvesting (EH) definition

- EH is the conversion of small quantities of environmental energy that would otherwise be wasted to power devices in the same place where energy is converted.

Macro

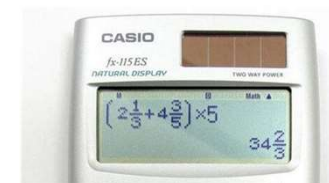
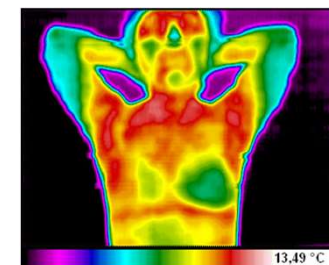


Heat

Mechanical energy /
Vibrations

Solar energy /
Light

Micro



EH is an old concept...

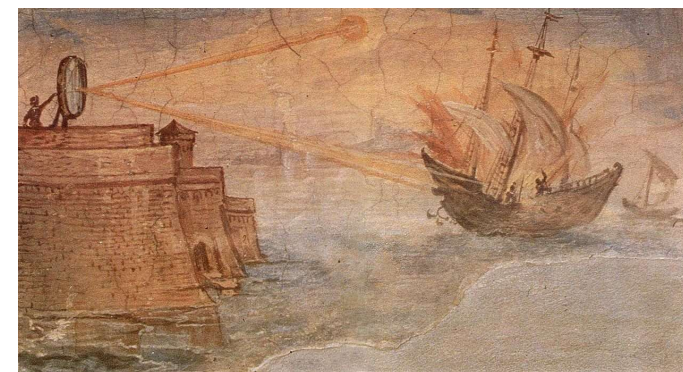
- Before the spread of electricity, EH was the only available way to avoid the humans/animals work



Water mill with flour groundstone

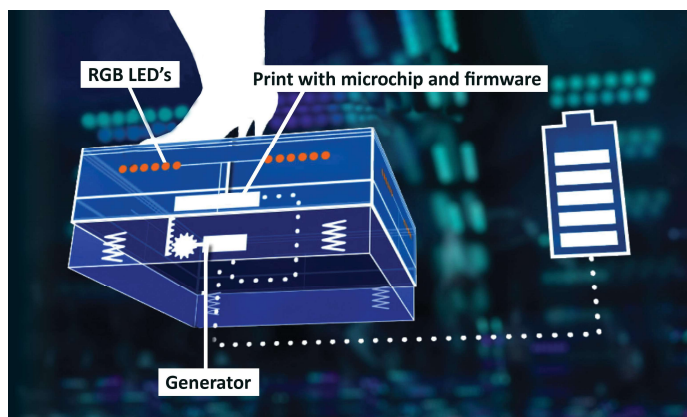


Nebraska farm in the early 1890



Burning mirrors, Giulio Parigi
(1600, Uffizi Gallery, Florence)

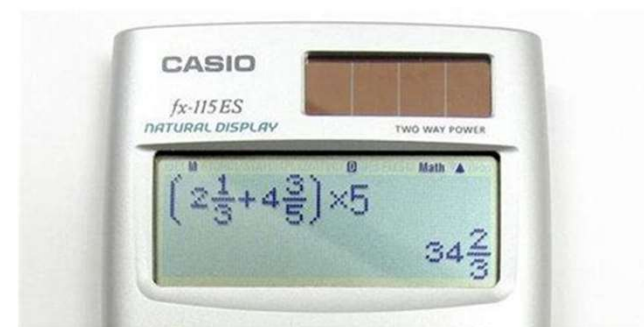
What is NOT Energy Harvesting!



These are examples of energy stealing...

Photovoltaic energy harvesting

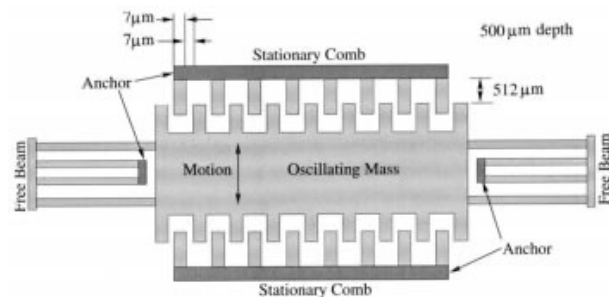
- It's a common relatively cheap solution;
- Can have deterioration of performances if not cleaned;
- Can be easily vandalized or damaged (birds...)



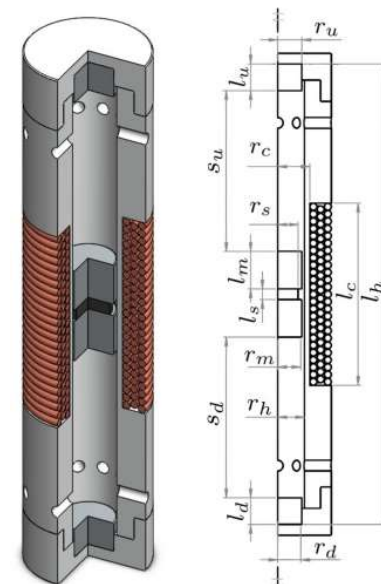
- Several examples:



Hand light torch



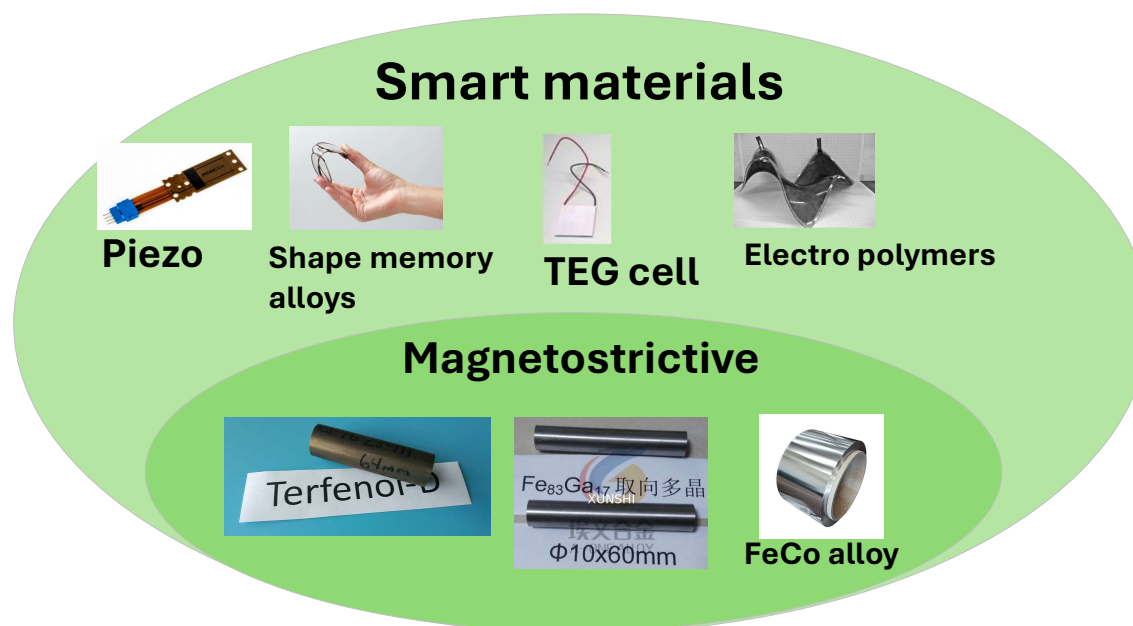
Electrostatic (capacitive) MEMS
(Micro Electro-Mechanical Systems)



Electromagnetic linear generators

Smart materials are the best candidates for EH!

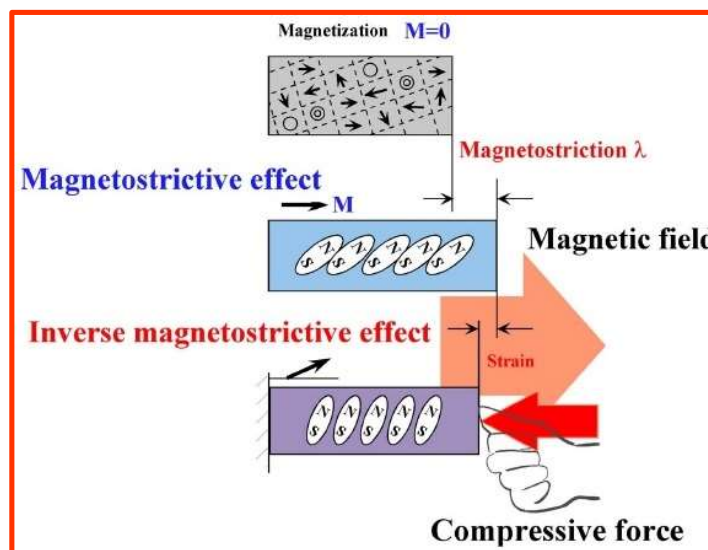
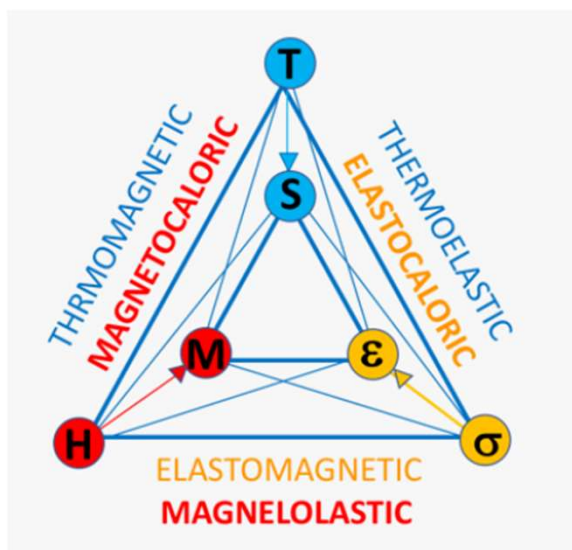
- They alter certain characteristics, such as shape, length, electrical and magnetic properties, when subjected to external stimuli like temperature, electric field, magnetic field, mechanical stress, or light.



They are also said «multifunctional» materials

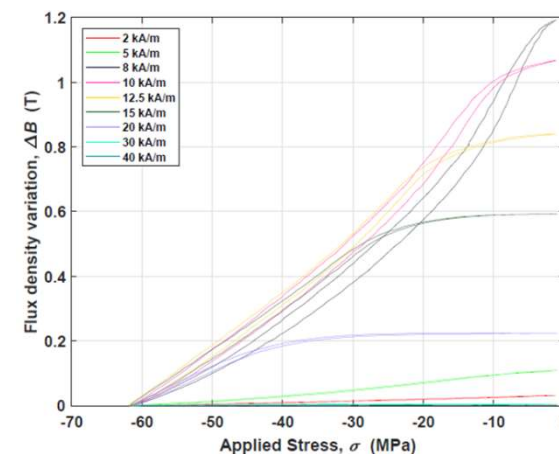
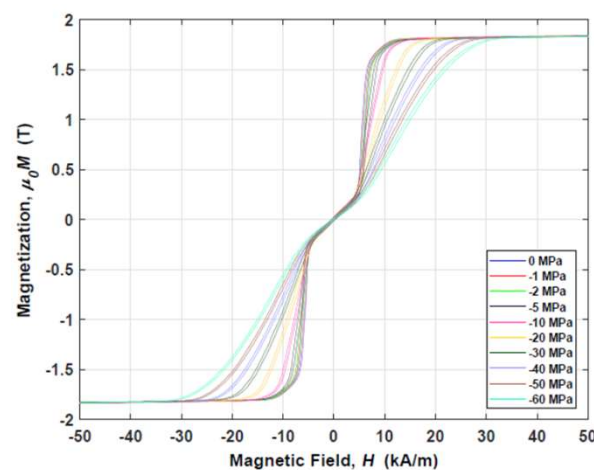
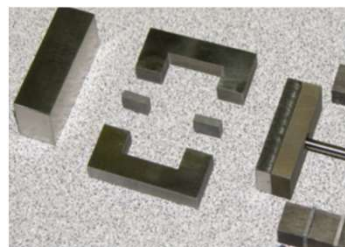
Magnetostrictive materials

- In magnetostrictive's, mechanical quantities (stress and strain) and magnetic quantities (magnetization and magnetic field) are linked



Galfenol (iron gallium alloy)

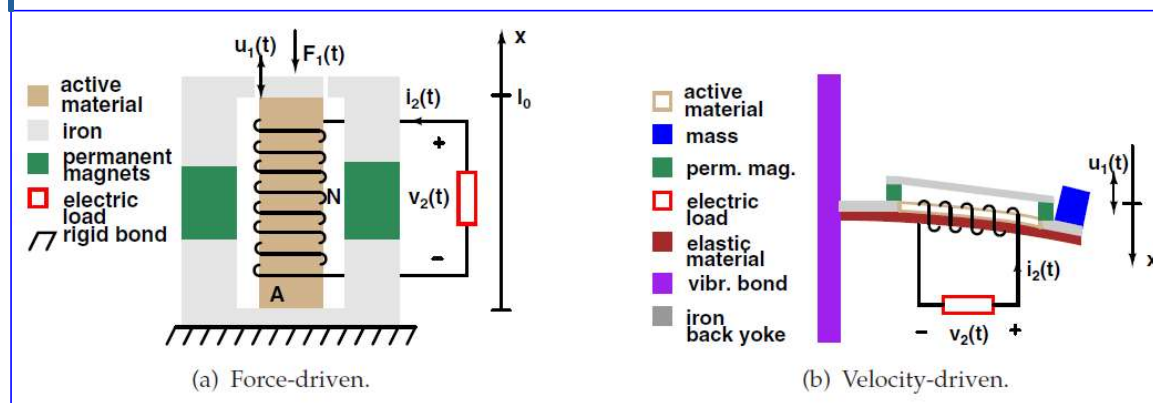
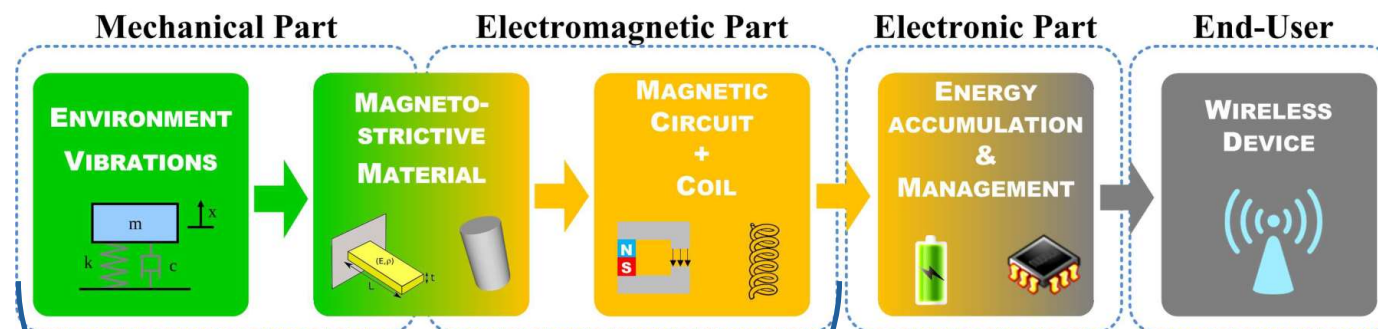
- Easily machinable
- High maximum magnetization
- Very narrow hysteresis loop
- Magnetization (M) decreases by increasing the stress (T) at the same magnetic field (H)
- by increasing the H also increases M , until saturation
- non-linear behaviour, “quasi-linear” behaviour in origin.



Magnetostrictive kinetic energy harvesters (KEH)

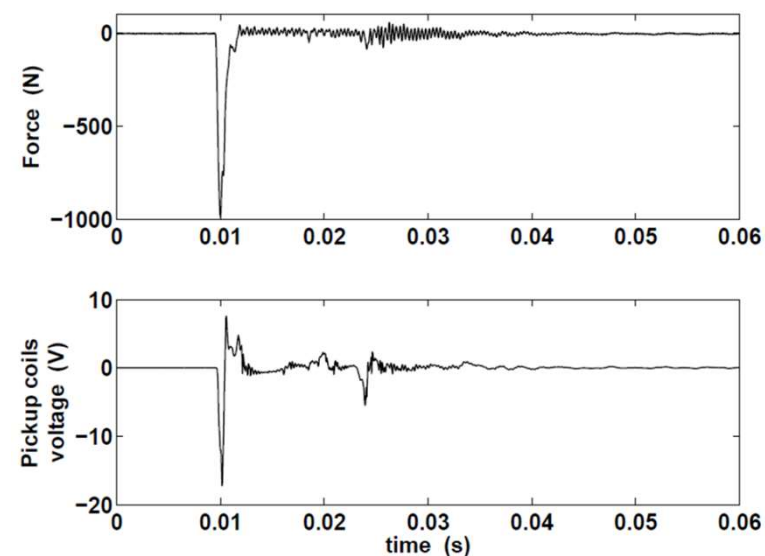
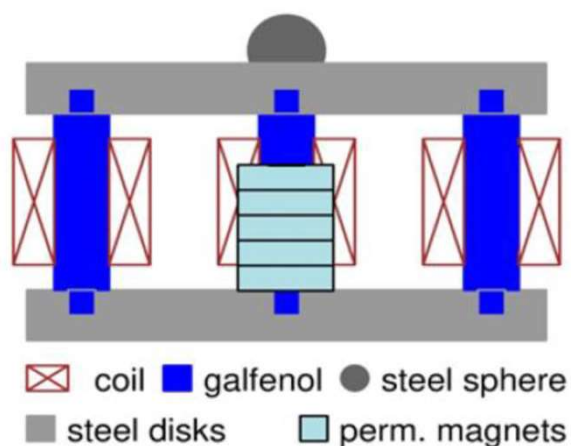
Two different kinds of kinetic harvesters:

- **Force driven** (or direct force): The force source is in mechanical direct contact with the active material in the so-called longitudinal mode.
- **Velocity-driven** (or inertial): exploits the inertial forces of proof mass oscillations induced by a vibrating bond;



KEH: an example of a three-rod galfenol harvester

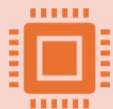
- Designed, built and tested @ DING – Unisannio
- A single pulse of hundreds of N gives tens of V, mW power, hundreds of mJ



Conclusions



Energy Harvesting (EH) is a sustainable solution for the needs of IoT paradigm;



EH is strengthened by smart materials exploitation;



EH is a multidisciplinary concept that makes profit of (low power) electronics, materials engineering, mechanical engineering,...

Research team @ DING - Unisannio



Dr. Ing. Daniele Davino
Full professor



Dr. Ing. Vincenzo Paolo
Senior researcher



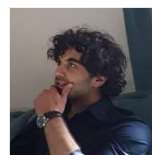
Dr. Ing. Carmine
Researcher



Ing. Vittorio Ciardiello
PhD student



Ing. Carlo Silano
PhD student



Ing. Attilio Di Matteo
Research grant holder

Contact: davino@unisannio.it

Thank you!