Horizon 2020
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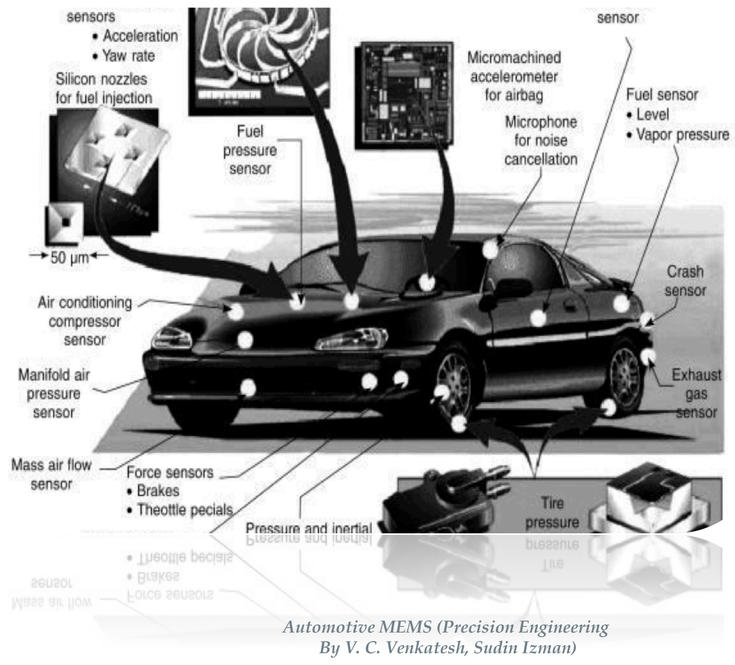
The Initial Training Network ENHANCE
Piezoelectric Energy Harvesters for Self-Powered Automotive Sensors from Advanced Lead-Free Materials to Smart Systems

Introduction

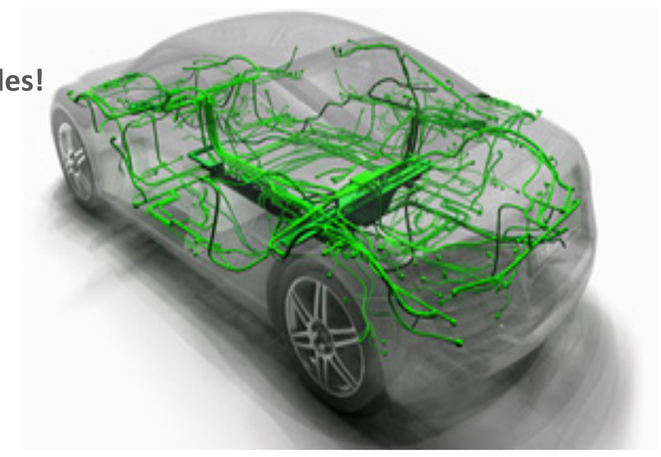
The ENHANCE project is an interdisciplinary, structured programme to form 13 young PhD researchers that will be hired and supervised by our partners: 7 European universities and 6 industrial partners expert in cutting-edge hybrid systems.
It is based on the multidisciplinary coordinated research activity across multiple scientific fields such as chemistry, materials science, physics, mechanics engineering and electronics.



Automotive MEMS (Precision Engineering By V. C. Venkatesh, Sudin Izman)

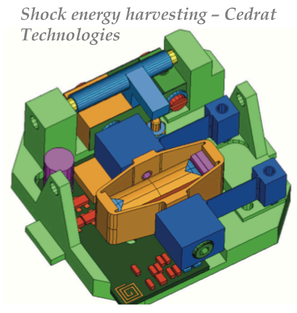
Challenges to overcome:
- Weight
- Complexity
- Cost of maintenance
- Sensibility to corrosive environment

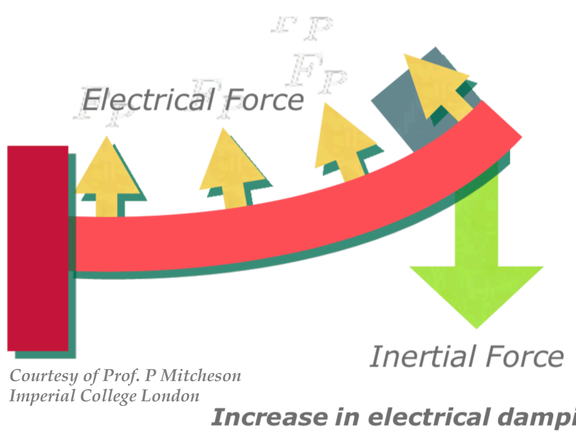
Up to 50 kg of cables!



MEMS sensors in future vehicles:
- Autonomous
- Wireless
- Maintenance-free

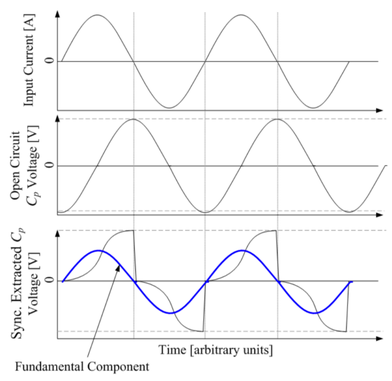
Shock energy harvesting – Cedrat Technologies





Courtesy of Prof. P Mitcheson Imperial College London

Increase in electrical damping

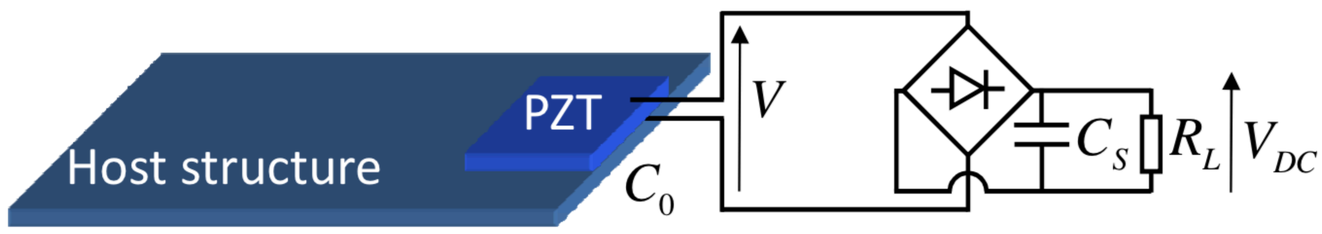


Improved power factor

Requirements:
- Compatible with available and variable vibrations in the range of 100-500 Hz
- Si compatible technology for direct integration with MEMS sensors
- Metalic substrates (flexibility, higher thermal expansion)
- Continuous supply of energy for sensor
- Size < 1 cm^3
- At present 100s $\mu W/cm^2/g^2$

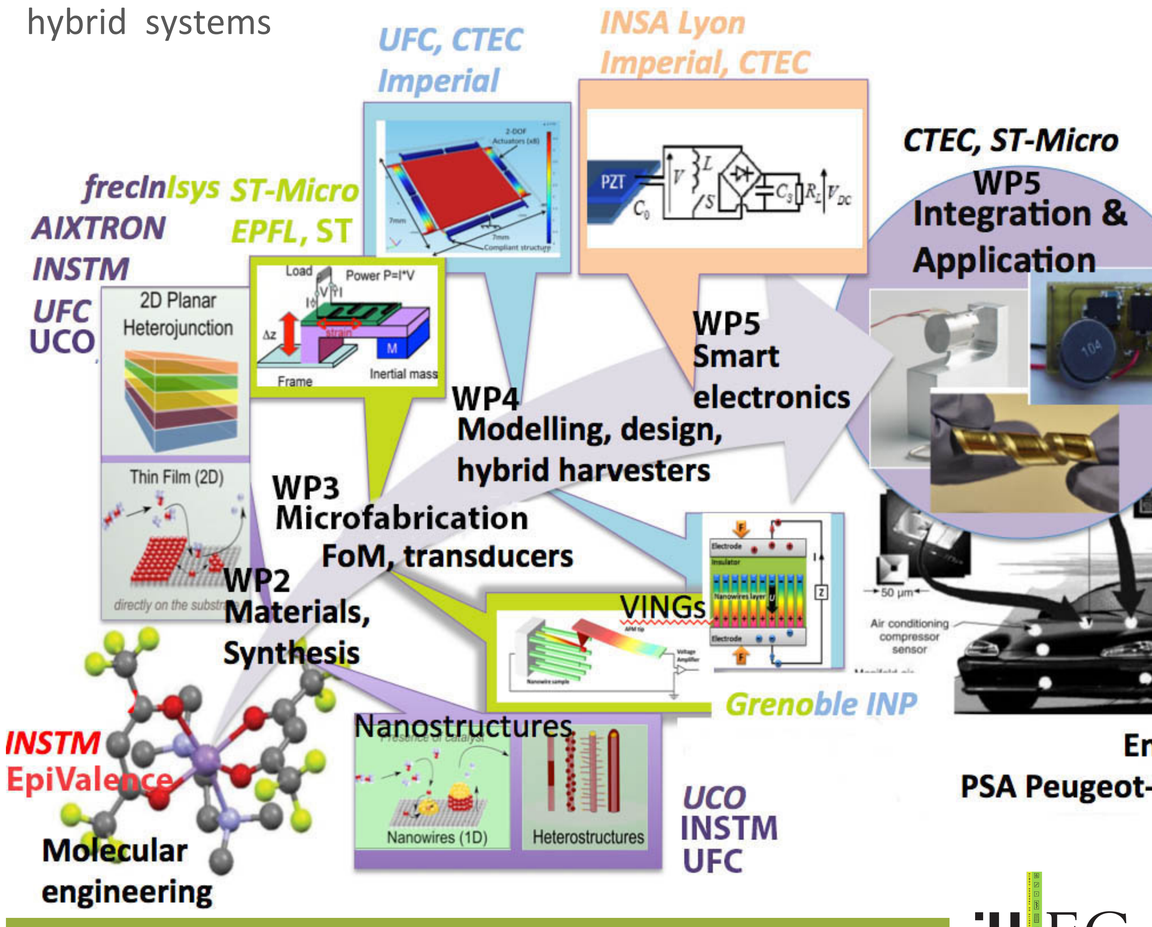
What we will develop

- Harvesters with stabilized output voltage in the 1-3 V range (300- 500 $\mu W/cm^2/g^2$) and capable to operate at temperatures as high as 600°C.
- Hybrid scavengers of energy already available in cars: (heat (Th)– light (Lt) vibrations (Vi) by seeking multiple conversion effects (piezoelectric (Pi) - pyroelectric (Py) – electromagnetic (EM) – photovoltaic (PV) employing piezo-ferroelectric-films-nanostructure technologies
- Efficient and long-life energy storage
- Time-cost efficient, and seasonably priced simplified fabrication of hybrid systems

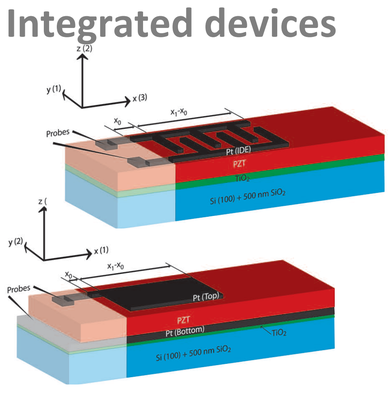


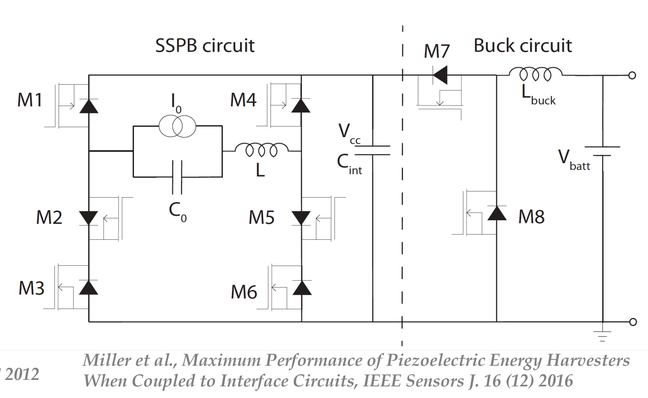
Courtesy of Dr. M. Lallart – INSA Lyon

Combined multidisciplinary approach:
- Advanced materials (FOM = 10-20 GJ/m^3)
- Optimized design of harvesters (max deflexion, degrees of freedom)
- Electronics (CMT – x 6 efficiency; multifrequency- 25%)
- Hybrid energy harvesting (ex. vibrational/thermal – increase 10%)



Integrated devices



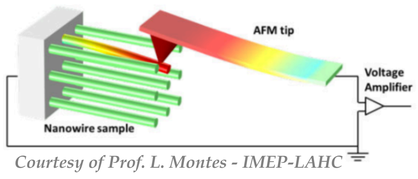


N. Chidambaram, A. Mazzalai, P. Muralt, IEEE TUFFC 2012

Miller et al., Maximum Performance of Piezoelectric Energy Harvesters When Coupled to Interface Circuits, IEEE Sensors J. 16 (12) 2016

Nanostructures
- Elasticity without cracking
- Able to convert several different mechanical energies
- Up-scalling & cost
- Environmental issues

S. Lee et al., Adv. Funct. Mat., 2013



Courtesy of Prof. L. Montes - IMEP-LAHC

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