Electret Basics and Energy Harvester Circuit

Graphene-based Energy Harvesting
SURP 2021

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Overview

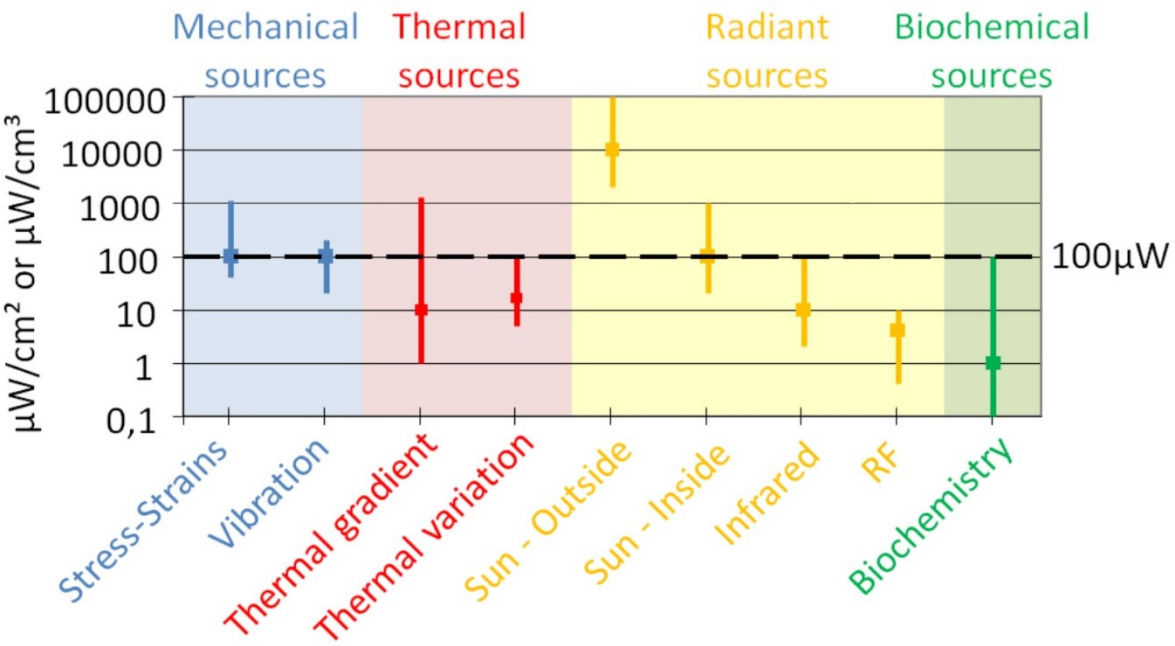
Ambient Energy Harvesting

Electrets

Electret-based Energy Harvester

Fluctuation Induced Current in freestanding Graphene

Article by Boisseau et al.



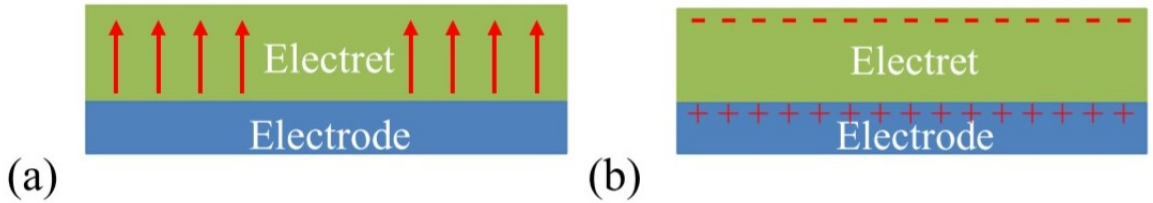
- $\mu W/cm^2$ order

Vibrational Energy Harvesters

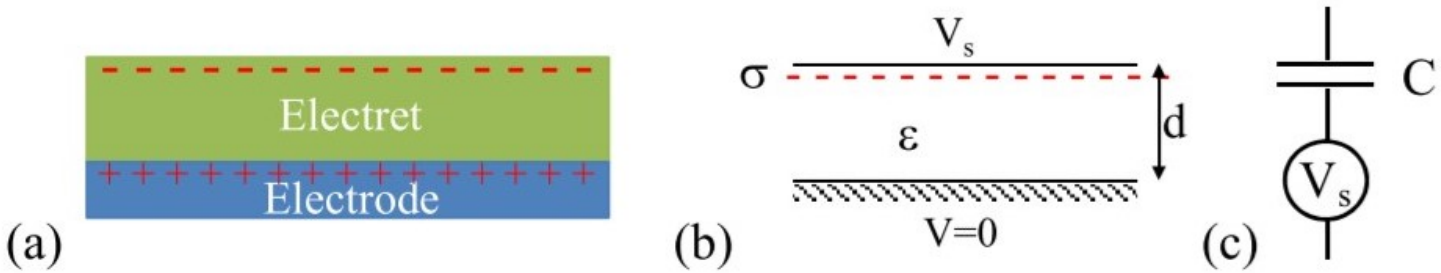
- To convert Vibrations into Electrical Power
  - Piezoelectric Converters
  - Electromagnetic Converters
  - **Electrostatic Converters** (Variational Capacitor)
- Electrostatic Converters:
  - Electret-free electrostatic converters (an active electronic circuit is then required)
  - Electret-based electrostatic converters

Types of Electret Materials

- Electrets are dielectric materials that are in a quasi-permanent electric polarization state (electric charges or dipole polarization)



- Equivalent Substitute in the circuit:

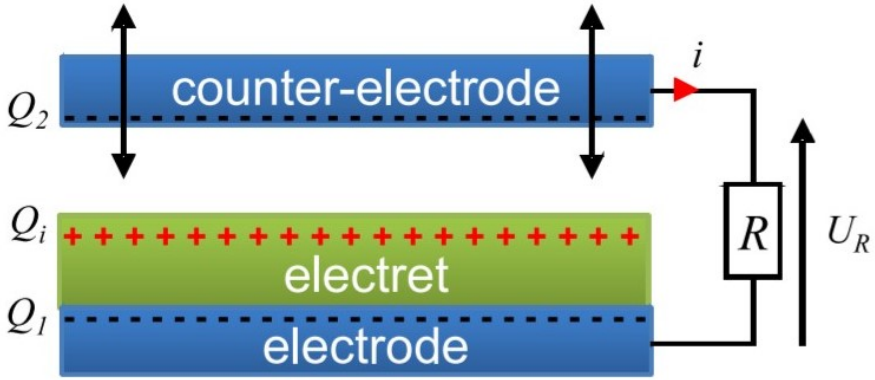


Electret Properties

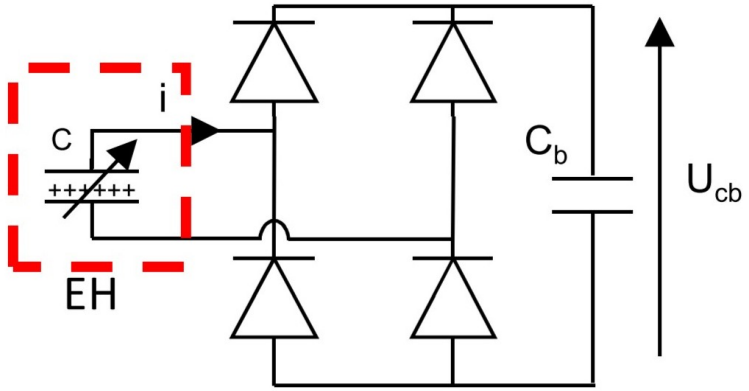
- For vibration energy harvesters, a relevant quantity is the Surface Potential Decay (SPD), that is to say, the electret's surface voltage as a function of the time after charging.
- Initial Surface Voltage & the Dielectric material used to make the Electret determine the Electret Stability.
- Generally, for a given material, the higher the initial surface voltage is, the lower the stability becomes.

Electrostatic Conversion

- Electret-based Electrostatic Converter



- Power Converter & Storage (Passive)



Some Limits

- Ambient vibrations are characterized by a low frequency, generally lower than 100Hz. Moreover, when looking at the vibrations spectra, it appears that they are spread over a wide frequency range This implies that we need to develop **low-frequency broadband devices**
- Electret stability & Precise Gap Control

Paper by Paul Thibado et al. (Oct 2020)

- A model in which fluctuating freestanding graphene and STM tip act as moving plates of a variable capacitor coupled to diodes and battery that supplies dc voltage
- Long time averages of dissipated power at one diode are exactly the same as long time averages of power supplied by the thermal bath
- Continuous Thermal power can be supplied by a Brownian particle at a single temperature while in thermodynamic equilibrium, provided the same amount of power is continuously dissipated in a resistor (load?).