

# 年吉研究室

## [MEMS for Frugal Electronics Technology]

生産技術研究所 マイクロナノ学際研究センター

Center for Interdisciplinary Research on Micro-Nano

<http://toshi.iis.u.tokyo.ac.jp/toshilab/>

マイクロマシンシステム工学 (生産研) / 極小デバイス理工学 (先端研)

工学系研究科 電気系工学専攻 (電気電子工学コース修士・博士課程) / 先端学際工学専攻 (博士課程)

Downscaling in size of microelectronics predicts a new era of distributed wireless sensor network, so-called the trillion-sensors of the Internet-of-Things (IoT) as a potential application of the More-than-More type electronics empowered by the vital added values of integrated micro electromechanical systems (MEMS). Besides the importance of sensors, autonomous energy sources are indispensable for specific applications. Recent R&D on

### MEMS for FRUGAL ELECTRONICS

Physical

MEMS Energy Harvester (Vibration-type) ~ 1 mW

Base Metabolism ~ 1500 kcal/day

Caloric Intake ~ 2200 kcal/day

Brain ~ 60W

Heart Beat

Diaphragm Motion

Implantable MEMS Energy Harvesters 10 ~ 100  $\mu$ W

Wireless Sensor ~ 100  $\mu$ W

Wrist Watch ~ 10  $\mu$ W

Physical 10 mW

Physical 10 mW

Power

Consumption

Generation

2010 2020 2030

Olympic Games in Tokyo

In-quantity	Applications to
✓ Human	$10^9$
✓ cars	$10^7$ /year
✓ phones	$10^8$ /year
✓ cards	$10^6 \sim 10^7$
✓ screws	???
✓ railroads	27000 km in Japan

H. Toshi 2016

MEMS energy harvesters (MEHs) are based on mainly three different principles including electromagnetic, piezoelectric, triboelectric, and electrostatic. Due to the potential compatibilities with the micro electronics, we have chosen the electrostatic inductive vibrational energy harvester based on the permanent electrical charge called "electret".