

# **Energy storage sources for autonomous IoT Sensing Devices**

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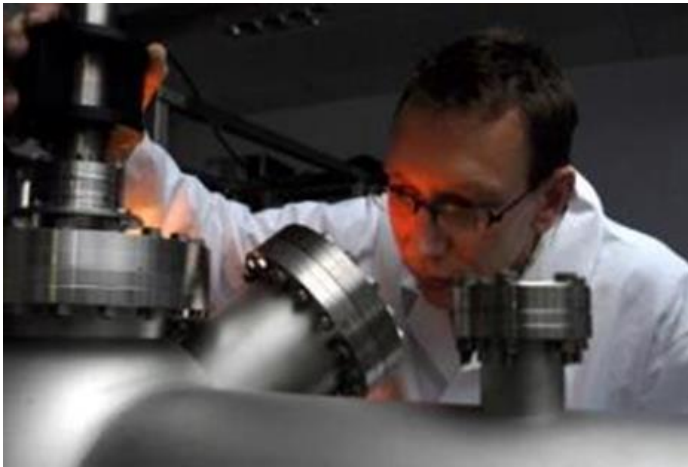
# OVERVIEW

- 1. Introduction**
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- 3. Solid State Batteries**
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- 5. Deployment Projects**

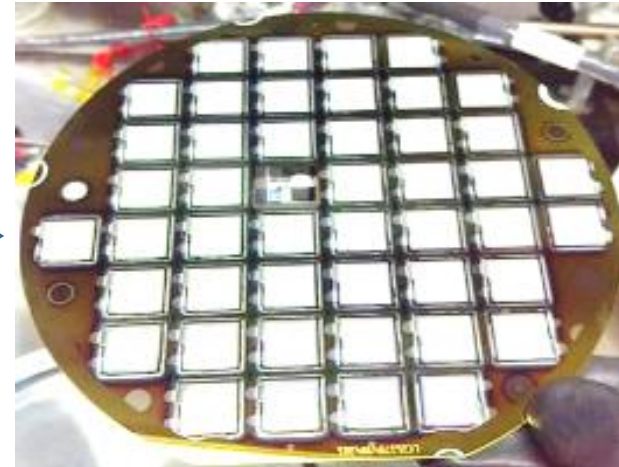
# 1 – Introduction

# Introduction to Ilika

Ilika's unique ability to rapidly discover new materials for the energy and electronics sectors



Innovation in Solid State Batteries used in many applications



**TOYOTA**

**APPLIED MATERIALS**



**Rolls-Royce**

**[dstl]**

**TOSHIBA**  
Leading Innovation >>>

**BOEING**

**Medical**  
**Internet of Things**  
**Harsh Environments**

## 2 - Challenges for Powering IoT Sensors

# Challenges for powering IoT sensors

- ▲ Long life
- ▲ Small-size unobtrusive, “invisible”, beacons for hard-to-reach places
- ▲ Reliability
- ▲ Safety, biocompatibility
- ▲ Low self-discharge for extended storage
- ▲ Changing batteries adds to Total Cost of Ownership

## ▲ Industrial



## ▲ Agriculture



## ▲ Transportation

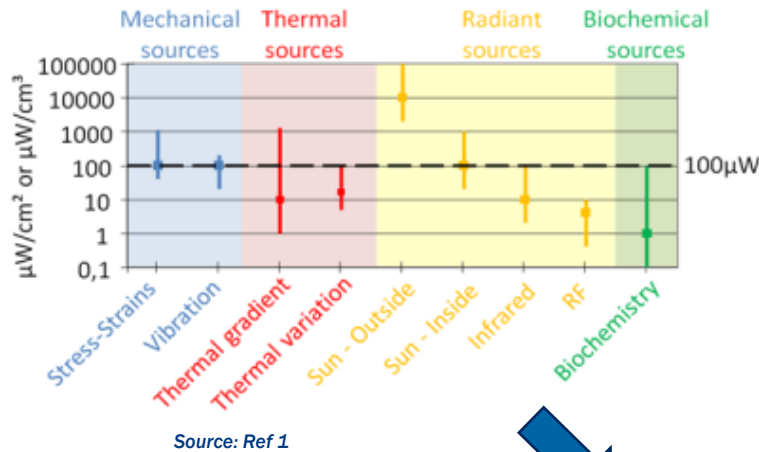


## ▲ Medical

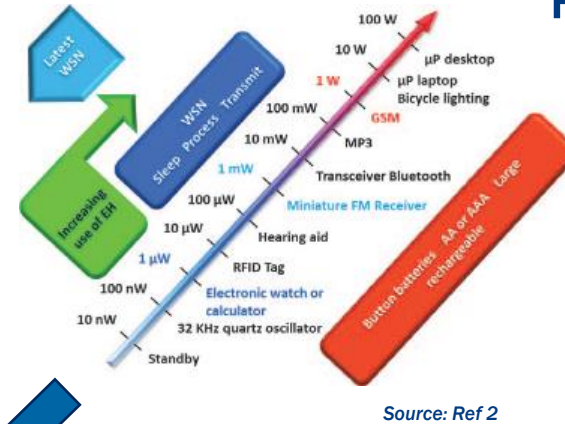


# Perpetual Beacons

## Efficient energy harvesters

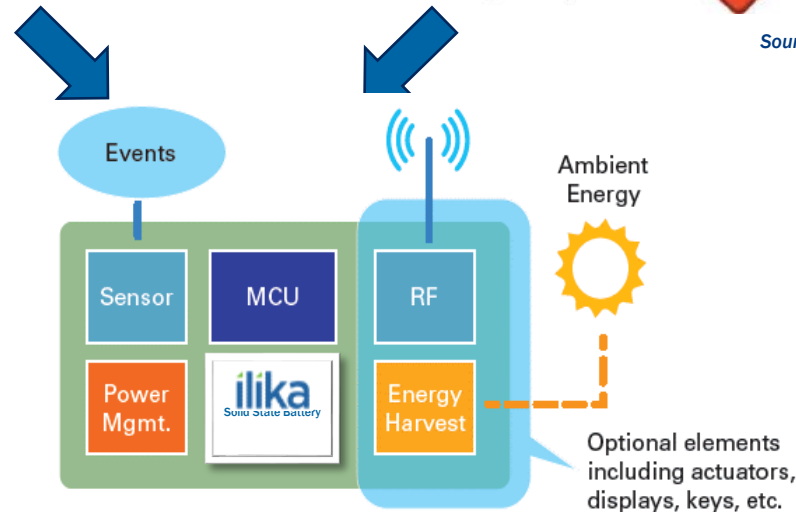


## Ultra low power electronics, sensors, communication and PMIC



## Micro-Batteries enable true "Leave for Life"

Source: Ref 3

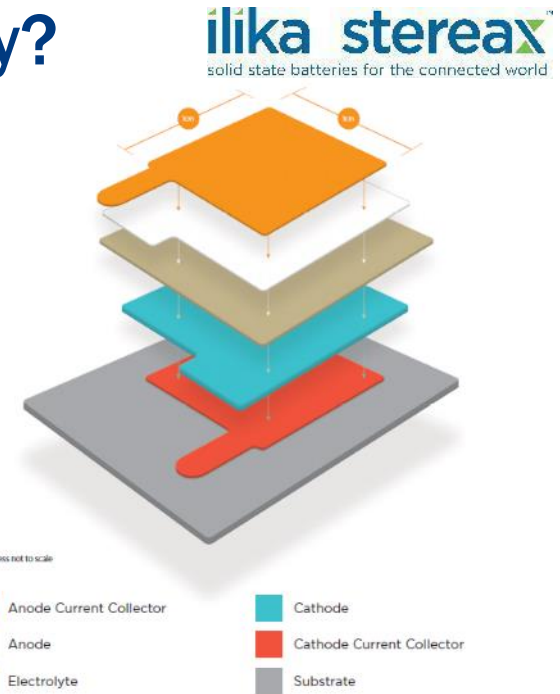
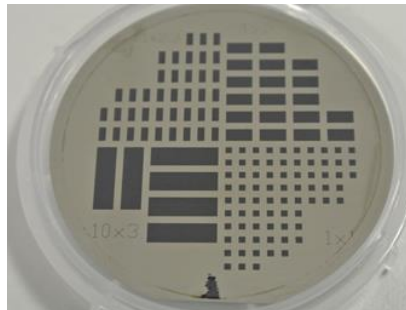


# 3 – Solid State Batteries



# What is a thin film solid state battery?

- ▲ Rechargeable Li-ion chemistry
- ▲ Deposited by evaporation and sputtering on wafer
- ▲ No liquid or polymer parts
- ▲ Advantages
  - ▲ Safety (no toxic liquid; biocompatible)
  - ▲ Long life (10 years)
  - ▲ Small size possible (to mm-scale)
  - ▲ Can be solder-reflowed
  - ▲ Can be integrated like an IC
  - ▲ Thermal stability to 150 °C
  - ▲ Low leakage (nA)
- ▲ Developments
  - ▲ High energy density
  - ▲ Stacking

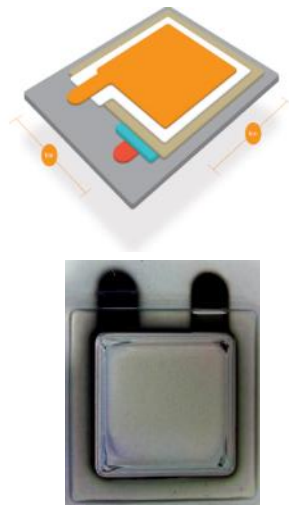


# Stereax<sup>®</sup> M250: Micro-battery for IoT applications

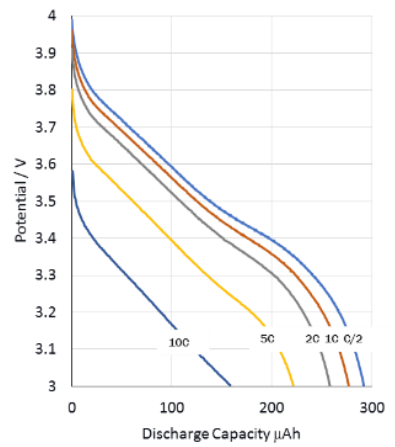


Parameter	Value
Capacity	250 $\mu$ Ah
Operational voltage range	3.0 - 4.0 V
Operational temperature range	-20 $^{\circ}$ C to +100 $^{\circ}$ C
Standard continuous current (1C)	250 $\mu$ A

Parameter	Value
Peak current	5 mA
Dimensions	12 mm x 12 mm (Note 1)
Battery Thickness	10 $\mu$ m (Note 2) + encapsulation
Cycle life (10% DoD)	5,000 cycles (to 80% of initial capacity)

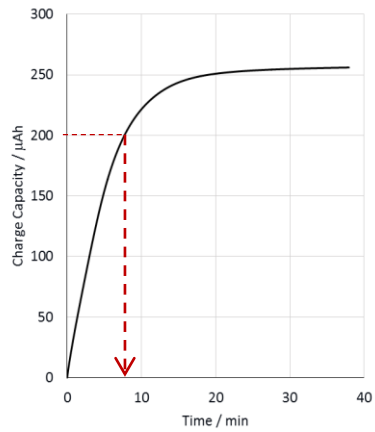


### High rate capability

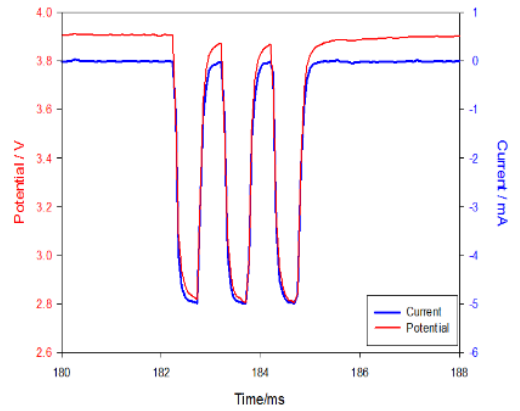


Note 1: Active footprint  
Note 2: Battery deposited on substrate (currently 650  $\mu$ m); Thinner substrates in testing (100  $\mu$ m); encapsulation 100  $\mu$ m

### 80% charge achieved in 8 min



### Appropriate for Bluetooth LE transmission

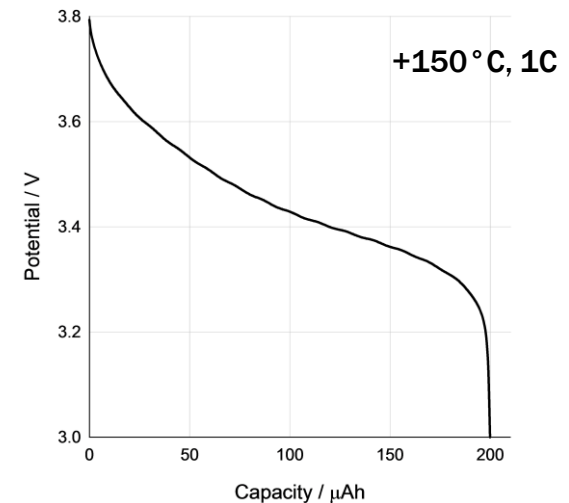
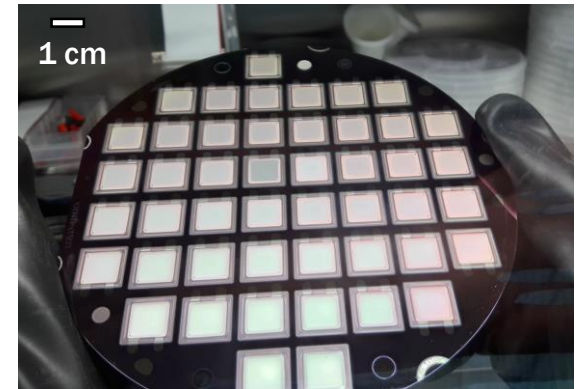


# Stereax<sup>®</sup> P180:

## Extended temperature range solid state battery

▲ Operate between -40 °C and +150 °C

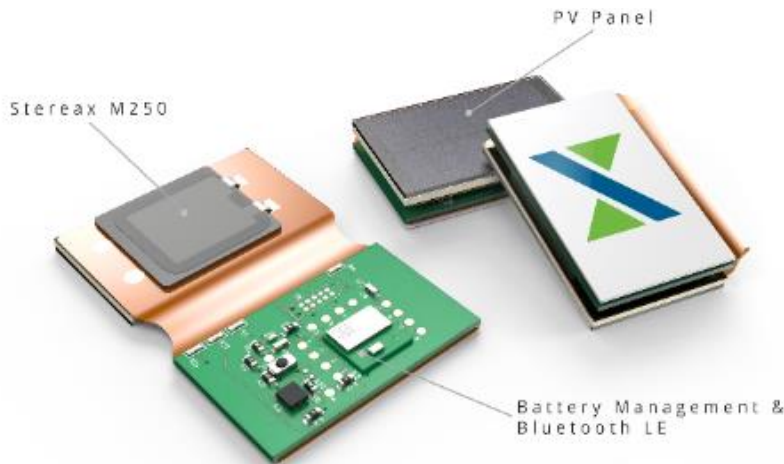
Parameter	Values at +150°C
Capacity	180 μAh
Operational voltage Range	3.0 – 3.8 V
Continuous Current	0.18 mA
Peak Current	18 mA
Dimensions	10 mm x 10 mm (Note 1)
Battery Thickness	~1 mm
Cycle Life (5% DoD, to 80% of initial capacity)	4000 cycles
Internal Resistance	15 Ω



## 4 – Integration Examples

# Demonstrators

## Perpetual Temperature Sensor for Smart Homes Operates 24/7



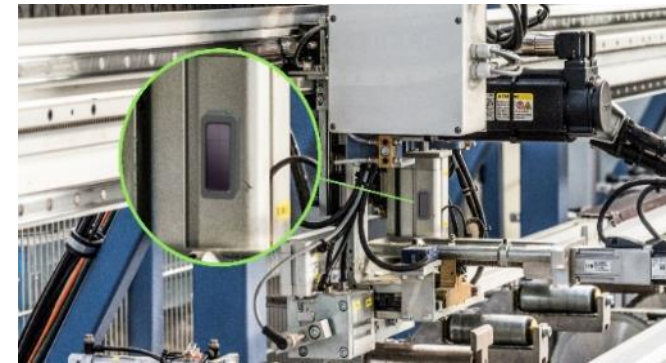
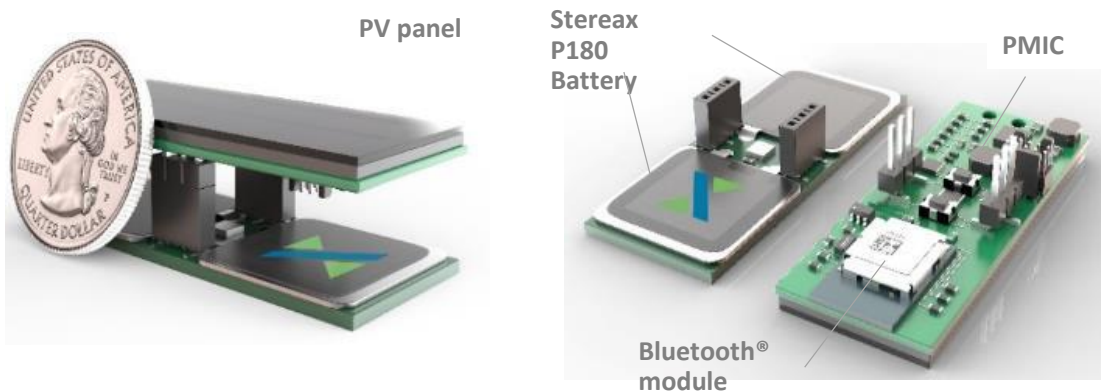
- ▲ **Scenario 1:**
  - ▲ Daytime 12 h (PV-powered); night-time 12 h (250 mAh) → 10 years life time
  - ▲ Corresponds to 4 x CR2032 coin cells
- ▲ **Scenario 2: BLACK-OUT**
  - ▲ Reduced frequency (5 min): 7 days life



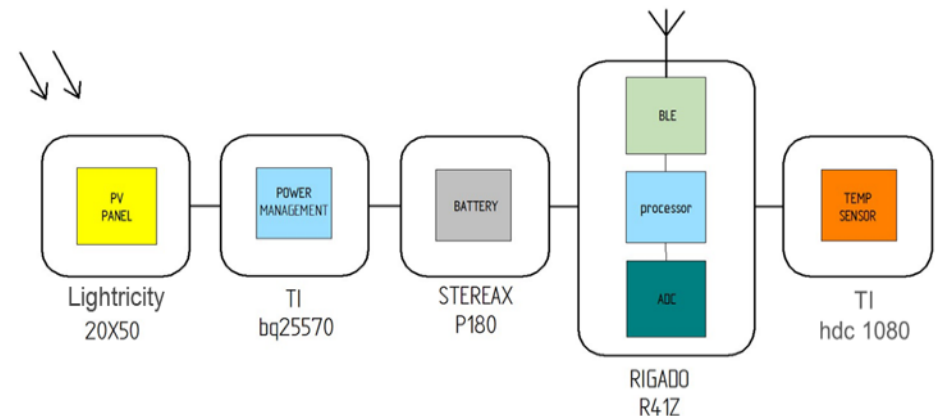
Component	Model	Comment
Battery	Stereax M250	250 $\mu$ Ah solid state battery
PV panel	IXYS SLMD600	35 mm x 22 mm
Battery Management	Texas Instruments	BQ25504 (incl. Temperature sensor)
Bluetooth LE	RICADO BMD-300	Nordic nRF52832 SoC with ARM Cortex M4F CPU

# Demonstrators

## Perpetual Sensor for Industrial IoT Operates to 150 °C

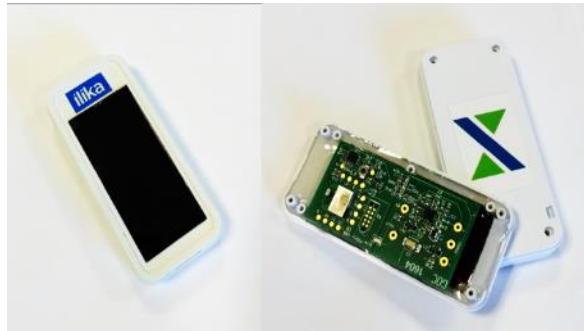


- ▲ A single transmission uses **28.5  $\mu$ A**s at full power (+4dBm)
- ▲ = **7.92 nAh** per transmission
- ▲ = **12626 transmissions** per **100  $\mu$ Ah** charge
- ▲ = **35 hours** of operation at **1 transmission every 10 seconds**
- ▲ = **100  $\mu$ J** per transmission
- ▲ at **3.5V**



# Demonstrators

## Plant Growth Monitoring for AgriTech Temperature, moisture, light level sensors



Component	Company	Model / Comment
Battery	ILIKA	2 x 250 $\mu$ Ah Stereax M250 solid state batteries
PV panel	Panasonic	AM-1801CA; 53 mm x 25 mm
Battery Management	Texas Instruments	BQ25570
Bluetooth LE	RIGADO	BMD-300, incl. Nordic nRF52832 SoC with ARM Cortex M4F CPU
Temperature and humidity sensor	Texas Instruments	HDC 1050
Light sensor	Texas Instruments	OPT3001



### Benefits

- Maintenance free
- Warning system
- Disease prevention
- Increased yield
- Optimised plant growth
- Prevention of livestock loss
- Lower cost of field and plant maintenance
- Long life



# 5 – Deployment Projects



# Deployment projects

## Smart Thin Power Source for Active Asset Tracking and Smart Homes



- ▲ Lightricity and Ilika are integrating their technologies into EH “Power Pack” module for Internet of Things
- ▲ Back-to-back integration
- ▲ Less than 2 mm thick
- ▲ <math>6\text{cm}^2</math>
- ▲ 1 mAh
- ▲ Up to 80 mW peak output
- ▲ 24/7 operation

**Innovate UK**  
**lightricity**



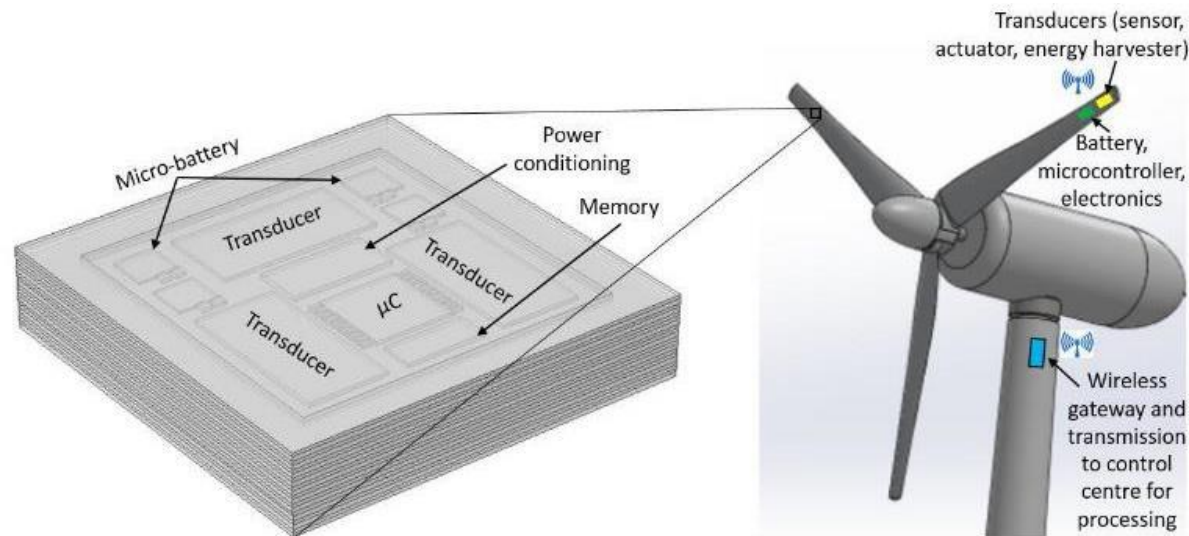
Lightricity ExcellLight high  
indoor efficiency  
a-Si Energy Harvester



Ilika Stereax  
solid state  
battery

# Deployment projects

## Condition Monitoring of Turbine Blades Vibration harvester and sensor



**Innovate UK**

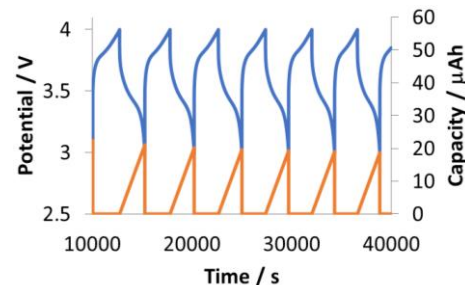
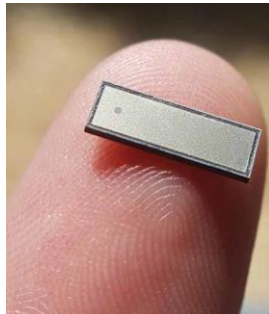


- ▲ Operation and maintenance cost of wind turbine: \$17bn
- ▲ Smart composite integrated vibration sensors
- ▲ Macro-fibre piezoelectric composite transducers used as vibration sensor and energy harvester
- ▲ Energy stored in solid state battery for 24/7 operation

# Deployment projects

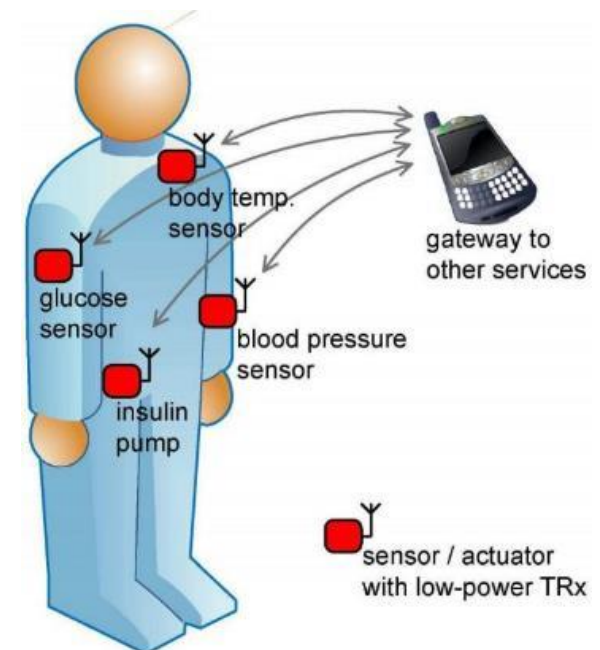
## Miniature Medical Implants

### Wireless charging



Study number	Cell viability (%)	Conclusion*
220668	102.7	Pass

- ▲ Small footprint: mm-scale
- ▲ Ultra-thin <math><250 \mu\text{m}</math>
- ▲ Various form factors including custom shapes and sizes
- ▲ Biocompatible encapsulants
- ▲ High energy density: 10's  $\mu\text{Ah}$
- ▲ SSB stacking increases energy density
- ▲ Low self discharge; leakage current: nAh's
- ▲ 6 months storage: regains 98% of initial capacity



# Call to action

- ▲ Ilika is looking to cooperate with:
  - ▲ System and component suppliers
  - ▲ Manufacturers
- ▲ To enable volume production for Stereax solid state batteries



# Conclusions

- ▲ IoT sensors require adapted power sources based on
  - ▲ Size
  - ▲ Power and energy requirements
  - ▲ Cost
  - ▲ Expected life
  - ▲ Operating temperature
- ▲ Various solutions exist for primary or secondary use cases
  - ▲ Conventional batteries (Lithium ion, button cells)
  - ▲ Supercaps
  - ▲ Solid state batteries
- ▲ Solid state batteries offer a small, size, long life, energy dense solution for wide operating temperature range

# Keep in touch!

Thanks a lot for your time and attention!

Any questions and/or comments?

▲ [www.ilika.com](http://www.ilika.com)

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▲  **/ilika-pl**



# References

- **1: Electrostatic Conversion for Vibration Energy Harvesting, S. Boisseau, G. Despesse and B. Ahmed Seddik; <https://www.intechopen.com/books/small-scale-energy-harvesting/electrostatic-conversion-for-vibration-energy-harvesting> OPEN ACCESS**
- **2: Internet of Things – Converging Technologies for Smart Environments and Integrated Ecosystems, Vermesan and Friess Ed., River Publishers**
- **3: Renesas - Energy Harvesting for Low-Power Sensor Systems – White Paper, February 2015**