

Review of Energy Storage Solutions for IoT Edge Nodes

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OVERVIEW

1. Introduction
2. Energy Harvesting
3. Challenges for Powering IoT Sensors
4. Energy Solutions
5. Integration Examples

1 – Introduction

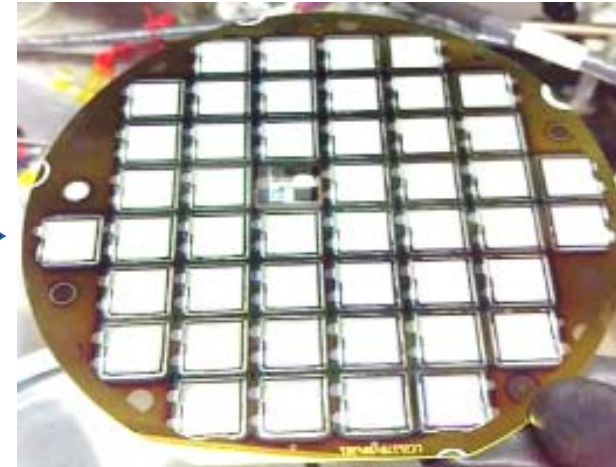
Introduction to Ilika



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



Created



Medical
Internet of Things
Harsh Environments

TOYOTA



Rolls-Royce



TOSHIBA
Leading Innovation >>>



2 - Energy Harvesting

Harvestable energy in IoT

IoT Market	Solar	Vibration	Thermal	Others
MedTech	Smart contact lens	Leadless pace-makers	Patches	Neuro-stimulators; leadless pace-makers
Industrial IoT	Predictive maintenance	Pumps, engines monitoring	Pumps, engines monitoring	RF
Smart Automotive	In-cabin environmental functions	TPMS	Engine, exhaust	RF
Smart Cities	Traffic monitor, bins, parking sensors			RF
Smart Homes	Environment monitors			
Infrastructure	Bridges, roads	Turbine blade monitoring; rails	Gas/oil pipelines	
AgriTech	Plant growth, cattle management			
Asset Tagging	Equipment locator			
Wearables	Smart watches and clothing			



Issues with harvesting energy

▲ Energy not always available to be harvested



▲ Intermittent source of energy



▲ Low output cannot power device in real time (energy and power)

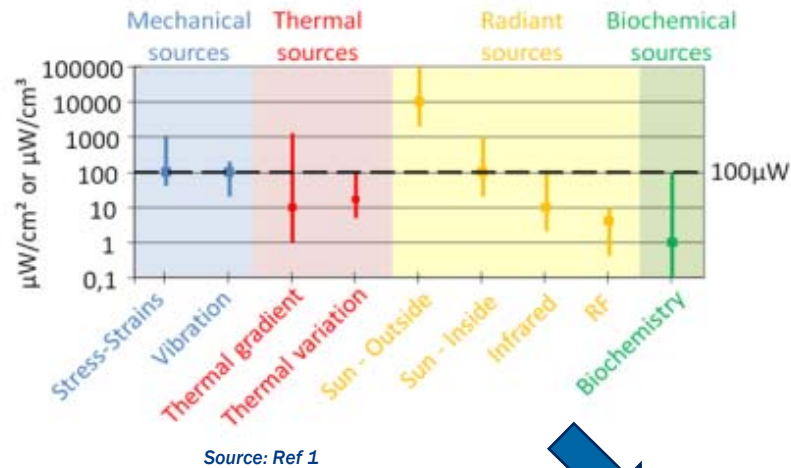


▲ Energy storage component required

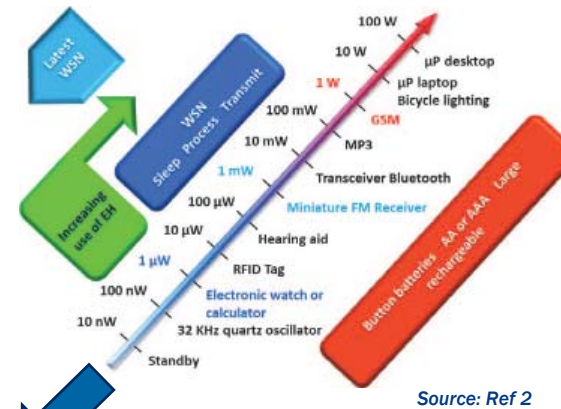


Perpetual Beacons

Efficient energy harvesters

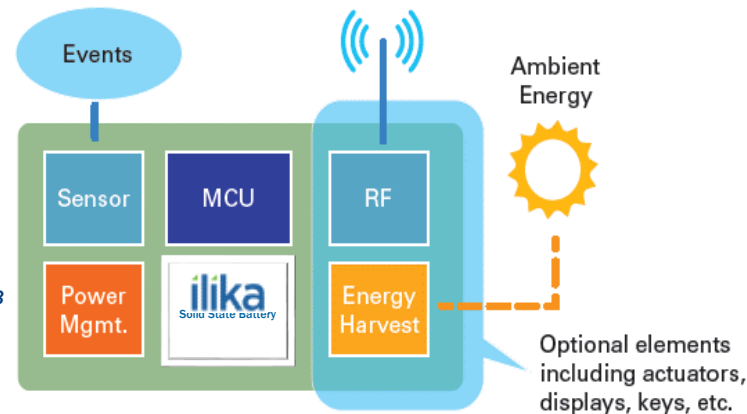


Ultra low power electronics, e.g. ARM Cortex



Micro-Batteries enable true "Leave for Life"

Source: Ref 3



3 - Challenges for Powering IoT Sensors

Challenges for powering IoT sensors

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

▲ Industrial



▲ Transportation



▲ Agriculture



▲ Medical



4 - Energy Solutions

Energy storage solutions

ilika stereax
solid state batteries for the connected world

Primary batteries



- Li/CF_x, Li/MnO₂, Li/SOCl₂, Zn air
- Single discharge
- Large capacity to Ah
- Prismatic, D-shaped, Cylindrical
- Highly packaged

Secondary batteries



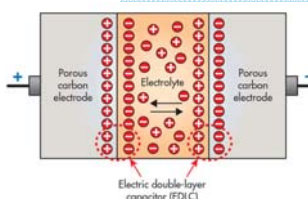
- Li-metal oxide
- 500-1000 cycles
- 2-5 years life
- To 100s mAh
- Smaller size than primary
- Need packaging

Li polymer



- Primary or secondary
- Gel/Polymer electrolyte
- Footprint in²/cm²
- Thin, Flexible
- Higher cost-to-energy ratio than lithium-ion

Supercaps (battery-free)

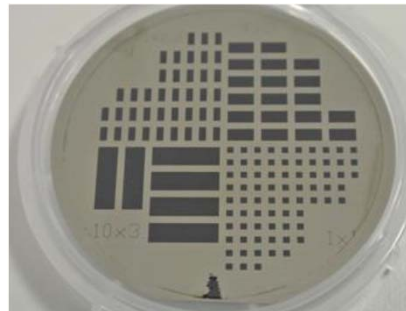
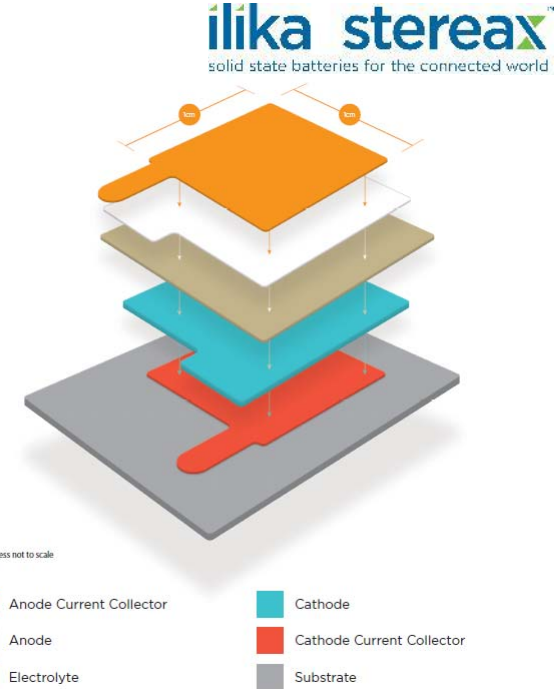


- Electric Double Layer
- Very small (mm)
- Many cycles (>100,000)
- High power
- Low energy density

Solid State Batteries

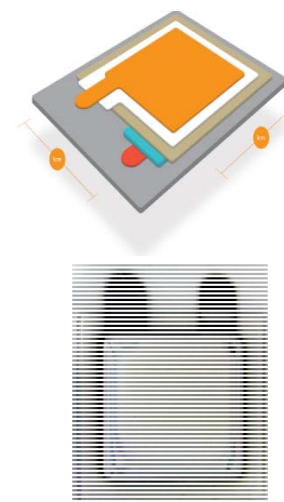
What is a thin film solid state battery?

- Rechargeable Li-ion chemistry
- Deposited by evaporation and sputtering
- No liquid or polymer parts
- Advantages
 - Safety (no toxic liquid; biocompatible)
 - Long life (10 years)
 - Small size possible (to mm-scale)
 - Thermal stability to 150°C
 - Low leakage (nA)
- In progress
 - High energy density
 - Stacking



Stereax[®] M250: Micro-battery for IoT applications

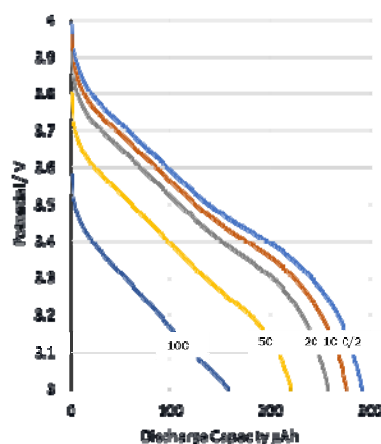
ilika stereax[®]
solid state batteries for the connected world



Parameter	Value
Capacity	250 μ Ah
Operational voltage range	3.0 – 4.0 V
Operational temperature range	-20°C to +100°C
Standard continuous current (1C)	250 μ A

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

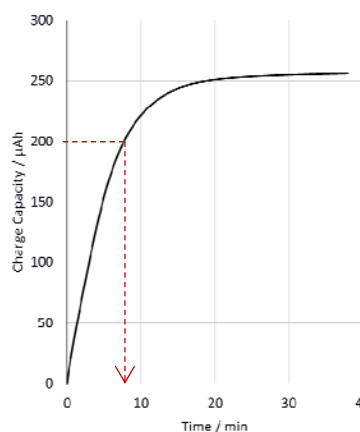
High rate capability



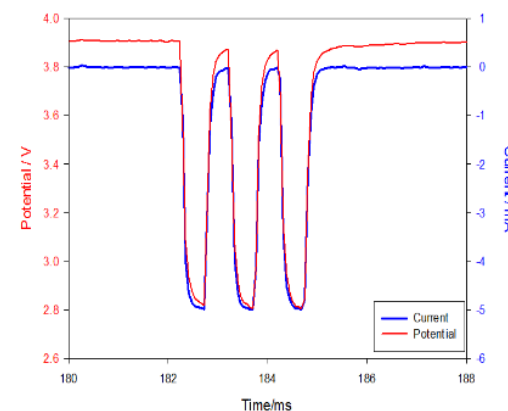
Note 1: Active footprint

Note 2: Battery deposited on substrate (currently 650 μ m); Thinner substrates in testing (100 μ m); encapsulation 100 μ m

80% charge achieved in 8 min



Appropriate for Bluetooth LE transmission

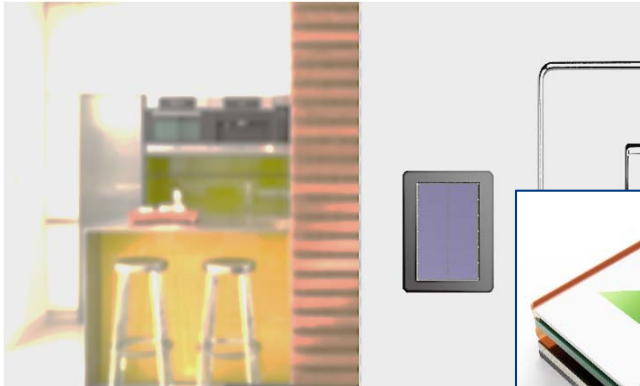


5 – Integration Examples

Ilika's Family of Perpetual Beacons

ilika stereax®
solid state batteries for the connected world

Smart Homes



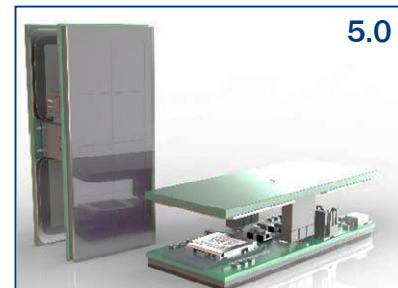
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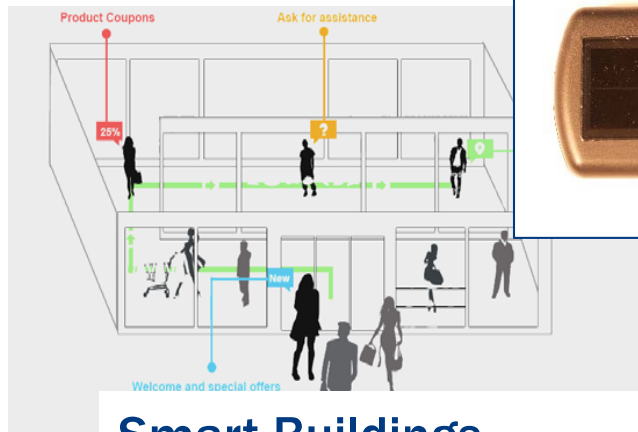
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5.0



Smart Buildings

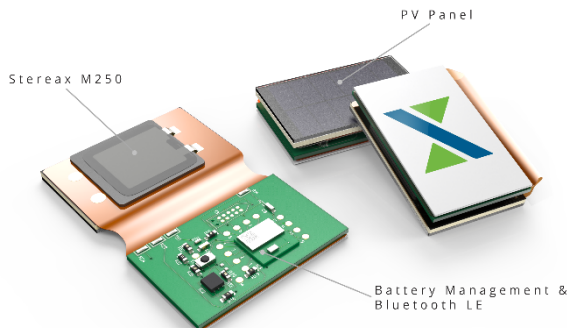


AgriTech



Industry 4.0

Temperature Sensor for SMART HOMES - SOLAR

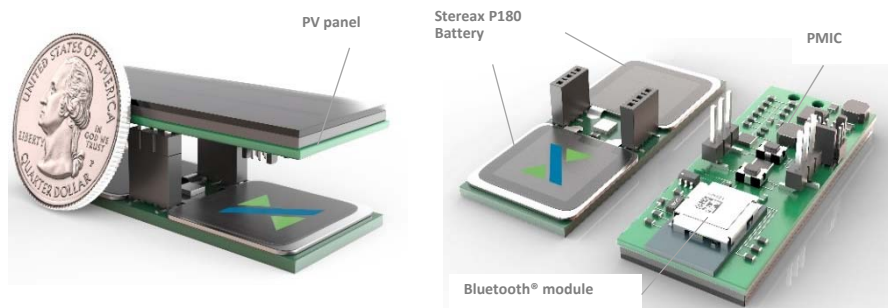


- 250 μ Ah SSB + PV panel
- 350 μ J per BLE transition
- 25h operation at 0.1 Hz
- Scenario 1:
 - Daytime 12 h (PV-powered); night-time 12 h (250 μ Ah) \rightarrow 10 years life time
 - Corresponds to 4 x CR2032 (change every two years)
- Scenario 2: BLACK-OUT
 - Reduced interval (5 min): 7 days

Component	Model	Comment
Battery	Stereax M250	250 μ 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



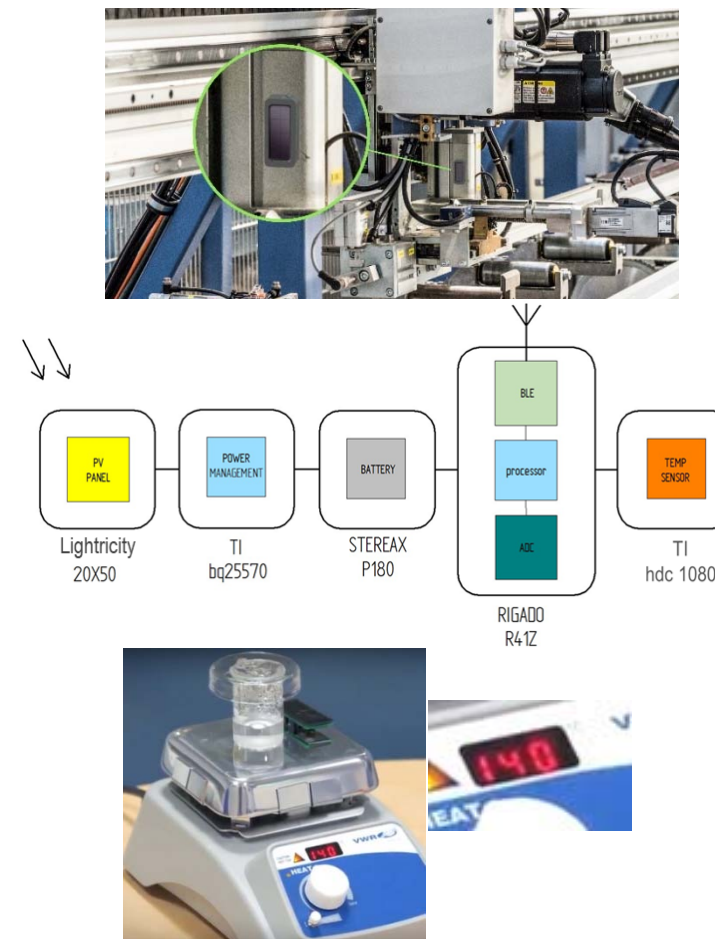
High Temperature Sensor for Industrial IoT - SOLAR



■ **Perpetual Beacons with temperature sensor powered by Solid State Battery and PV panel**

■ **Battery operates to 150° C**

■ **Device operates > 100° C**



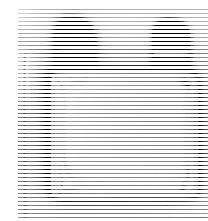
SMART Thin Power Source for Active Asset tracking - SOLAR



- Lightricity and Ilika are integrating their technologies into EH “Power Pack” module for Internet of Things
- Less than 2 mm thick
- <6cm²
- 1 mAh
- Up to 80 mW output
- 24/7 operation

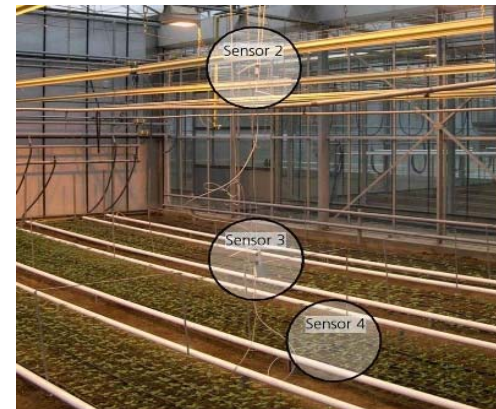
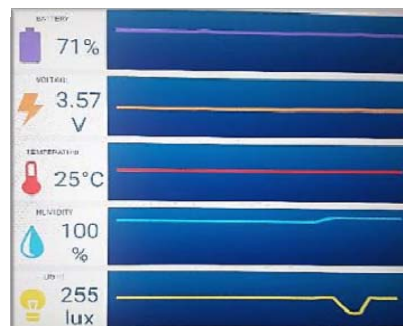
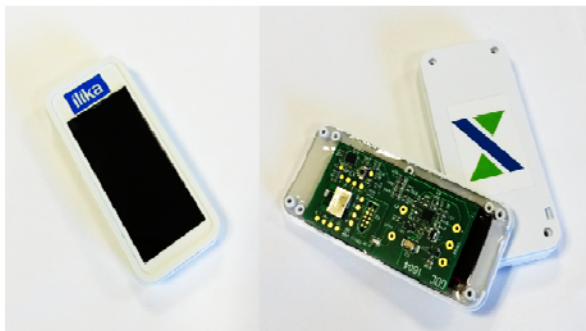


Lightricity ExcellLight high
indoor efficiency
a-Si Energy Harvester



Ilika Stereax
solid state
battery

Plant Growth Monitoring for AgriTech - SOLAR



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

Component	Company	Model / Comment
Battery	ILIKA	2 x 250 μ 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

Health Monitoring for Wind Turbine Blades - VIBRATION

- 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

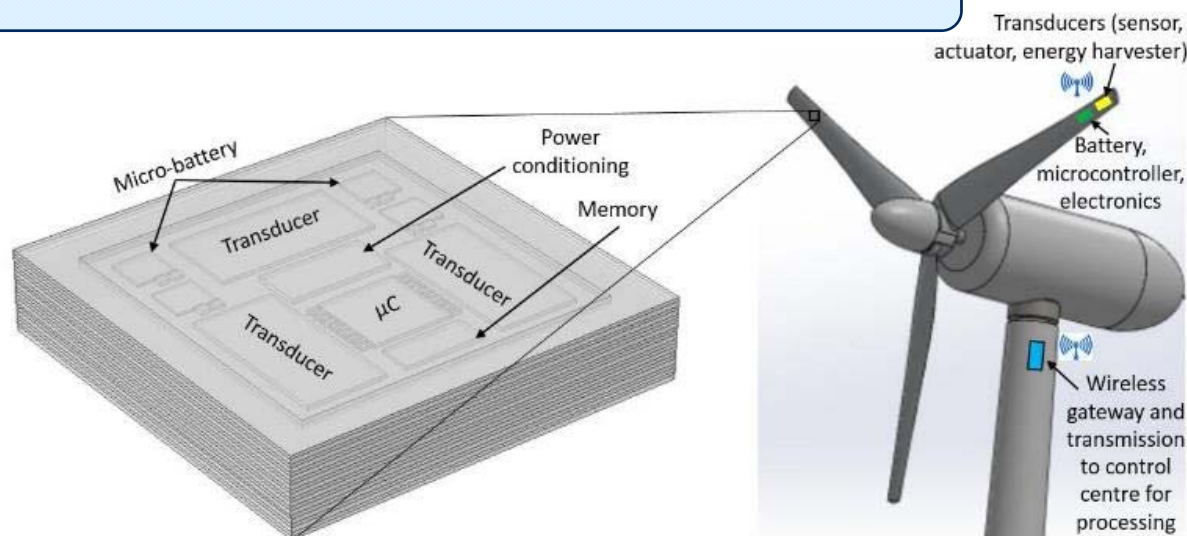
Innovate UK



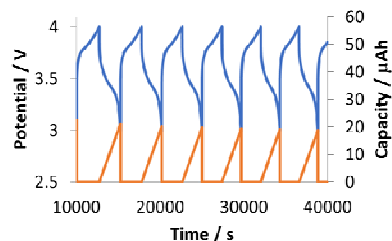
University of
Chester



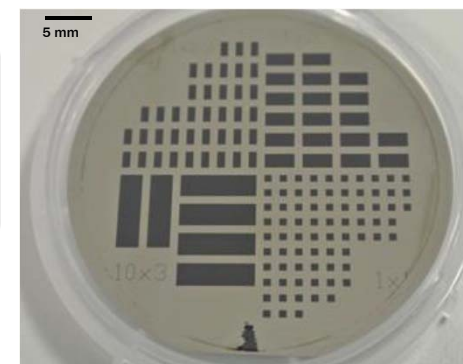
天顺风能
TITAN WIND



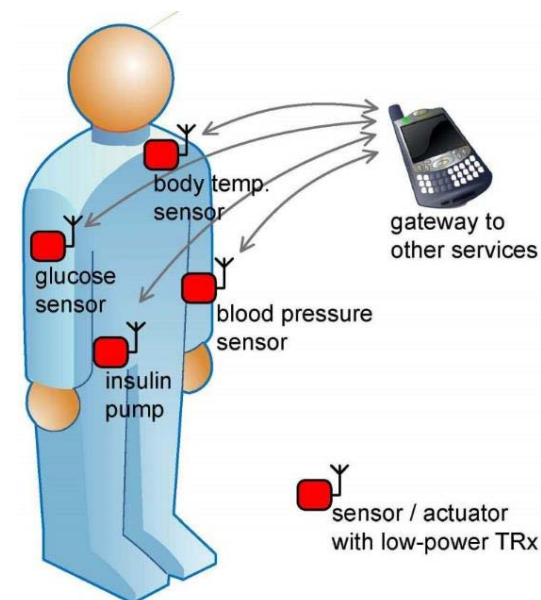
Miniature Medical Implants - WIRELESS



Study number	Cell viability (%)	Conclusion*
220668	102.7 <small>NAMSA, France, ISO 10993-5</small>	Pass



- Small footprint: mm-scale
- Ultra-thin <250 μm
- Various form factors including custom shapes and sizes
- Biocompatible encapsulants
- High energy density: 10's μAh
- 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

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▲  **/ilika-plc**



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