

Fully oxide-based zero emission & portable energy supply

A clean way to power wireless IoT devices



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Powering wireless IoT devices

The Internet of Things (IoT) enables the communication and interaction between different devices and is the backbone infrastructure behind many future-shaping concepts such as Smart Cities and Work 4.0. To be embedded into vehicles or machines, or to be placed into remote locations away from the power-grid, IoT devices need to be fully wireless, lightweight, and energy-autonomous. Providing efficient solutions for powering wireless devices is the key for unlocking the true potential of IoT.



INTERNET OF THINGS

Within the project FOXES we pursue an integrated and environmentally-sustainable approach to the problem of powering wireless IoT devices. Our goal is to realize what we call FOXES Power Cube — an integrated 2 x 2 cm² system, which combines a high-efficiency solar cell with a multilayer capacitor and an energy management circuit. And we want to achieve this using only low-cost and environmentally friendly processes and materials, so that the Power Cube will have no negative environmental impact at its end of life.

Marco Deluca, Project Coordinator (Materials Center Leoben Forschung GmbH, AT)

FOXES Goal

The goal of the EU-funded project FOXES is to develop FOXES Power Cube — a clean, compact, low-cost and scalable high-energy density solution for powering IoT devices such as wireless sensor nodes.

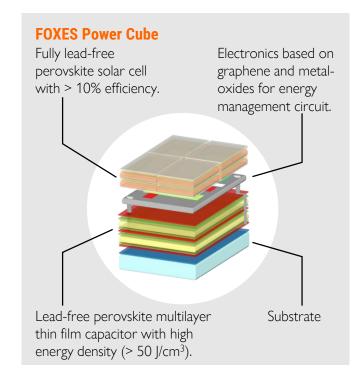
FOXES Power Cube combines:

- a high-efficiency solar cell
- a high-energy density multilayer thin-film capacitor
- an energy-management circuit

The device ensures autonomous operation of IoT devices, storing in the capacitor the solar-energy surplus generated by the solar cell, for being used when solar light is not available.

All components of *FOXES Power Cube* are monolithically integrated using low-cost and sustainable processes.

Targeted energy generation: > 250 mJ/day



A challenging test bed

The test bed of *FOXES Power Cube* is a custom-made airmonitoring system. One of the goals of the project is to develop a low-power IoT bundle formed by a light-activated gas sensors and by the necessary control and communication electronics. The combined system *FOXES Power Cube* + sensor node will be tested in the lab against gas mixtures under variable irradiation conditions. At the end of the project, FOXES demonstrators will be employed to realize and operate a net of wireless airquality sensors in the urban area of Barcelona.

"FOXES demonstrators will allow an unprecedented level of spatial resolution in monitoring emissions, facilitating the identification of problematic spots and the implementation of effective countermeasures."

J. Daniel Prades (Universitat de Barcelona, ES)

Technical objectives

Energy generating module

- Lead-free perovskite solar cell
- Energy efficiency: > 10%,
- Energy generation: > 6 μW/cm² (indoor illumination conditions, 400 lux)
- Output voltage: 4 V

Energy storage module

- Lead-free perovskite multilayer thin-film capacitor
- Energy density: > 50 J/cm³
- Full-capacitor charge: > 0.6 mJ (at 4 V input voltage)

Energy management circuit

Ensure full energy-autonomous operation of the IoT node

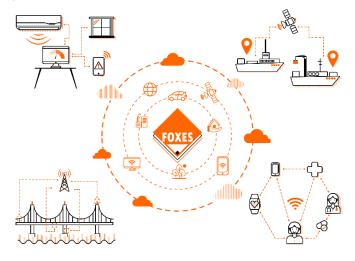
Gas sensors & IoT bundle

- Light-activated semiconductor gas sensor with operation power $< 10 \, \mu W$
- IoT bundle with operation power < 50 μW

Scaling up FOXES technology

The long-term vision of FOXES is to produce FOXES Power Cube as a modular system that can be custom-designed according to the application needs. Stand-alone energy supply systems could be constituted by several Cubes connected in parallel over a large surface, but still maintaining portability (e.g. $10 \times 10 \text{ cm}^2$).

This will open virtually infinite possibilities of applications, especially in areas where lightweight IoT devices and low-cost energy generation are decisive, such as sensors for autonomous driving, aeronautics, industrial process automation, GPS systems, and wearables. A roadmap for scaling up FOXES Power Cube will be defined within the project.



Sustainability

Sustainability is one of the keywords of the project. FOXES Power Cube will be free of toxic elements and with minimized use of rare raw materials. We strive for developing economically viable and eco-friendly fabrication processes without toxic or harmful substances as precursors.

FOXES Power Cubes will be core enablers for IoT devices for increasing the efficiency of transport and industrial processes, reducing fuel consumption and CO_2 emissions.

Project fact sheet

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