

# Ultralow power transistors could function for years without a battery

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A newly-developed form of transistor opens up a range of new electronic applications including wearable or implantable devices by drastically reducing the amount of power used. Devices based on this type of ultralow power transistor, developed by engineers at the University of Cambridge, could function for months or even years without a battery by 'scavenging' energy from their environment.

Using a similar principle to a computer in sleep mode, the new transistor harnesses a tiny 'leakage' of electrical current, known as a near-off-state current, for its operations. This leak, like water dripping from a faulty tap, is a characteristic of all transistors, but this is the first time that it has been effectively captured and used functionally. The results, reported in the journal *Science*, open up new avenues for system design for the Internet of Things, in which most of the things we interact with every day are connected to the Internet.

The transistors can be produced at low temperatures and can be printed on almost any material, from glass and plastic to polyester and paper. They are based on a unique geometry which uses a 'non-desirable' characteristic, namely the point of contact between the metal and semiconducting components of a transistor, a so-called 'Schottky barrier.'

"We're challenging conventional perception of how a transistor should be," said Professor Arokia Nathan of Cambridge's Department of Engineering, the paper's co-author. "We've found that these Schottky

barriers, which most engineers try to avoid, actually have the ideal characteristics for the type of ultralow power applications we're looking at, such as wearable or implantable electronics for health monitoring."

The new design gets around one of the main issues preventing the development of ultralow power transistors, namely the ability to produce them at very small sizes. As transistors get smaller, their two electrodes start to influence the behaviour of one another, and the voltages spread, meaning that below a certain size, transistors fail to function as desired. By changing the design of the transistors, the Cambridge researchers were able to use the Schottky barriers to keep the electrodes independent from one another, so that the transistors can be scaled down to very small geometries.

The design also achieves a very high level of gain, or signal amplification. The transistor's operating voltage is less than a volt, with power consumption below a billionth of a watt. This ultralow power consumption makes them most suitable for applications where function is more important than speed, which is the essence of the Internet of Things.

"If we were to draw energy from a typical AA battery based on this design, it would last for a billion years," said Dr Sungsik Lee, the paper's first author, also from the Department of Engineering. "Using the Schottky barrier allows us to keep the electrodes from interfering with each other in order to amplify the amplitude of the signal even at the state where the transistor is almost switched off."

"This will bring about a new design model for ultralow power sensor interfaces and analogue signal processing in wearable and [implantable devices](#), all of which are critical for the Internet of Things," said Nathan.

"This is an ingenious transistor concept," said Professor Gehan

Amaratunga, Head of the Electronics, Power and Energy Conversion Group at Cambridge's Engineering Department. "This type of ultra-low power operation is a pre-requisite for many of the new ubiquitous electronics applications, where what matters is function - in essence 'intelligence' - without the demand for speed. In such applications the possibility of having totally autonomous electronics now becomes a possibility. The system can rely on harvesting background energy from the environment for very long term operation, which is akin to organisms such as bacteria in biology."

**More information:** "Subthreshold Schottky-barrier thin-film transistors with ultralow power and high intrinsic gain"

[science.sciencemag.org/cgi/doi ... 1126/science.aah5035](https://science.sciencemag.org/cgi/doi/10.1126/science.aah5035)

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