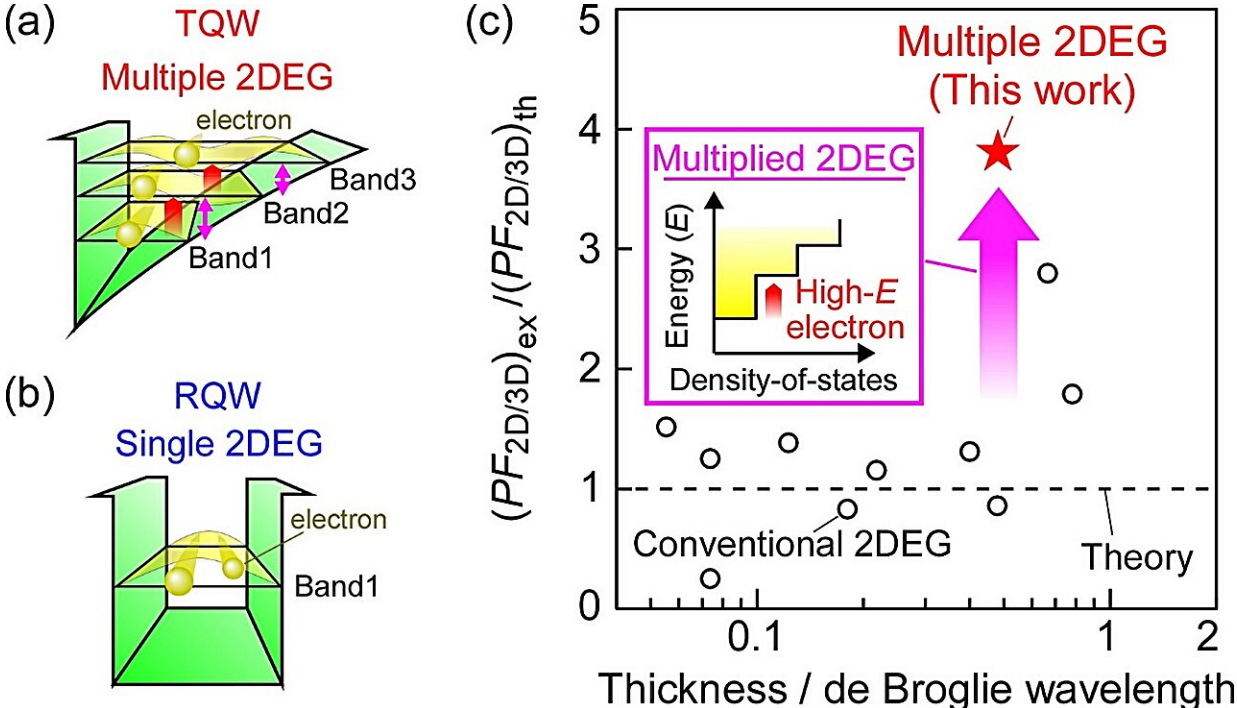


Advancement in thermoelectricity could light up the Internet of Things

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(a) Multiple subband in triangular quantumwell (TQW), (b) Single subband in rectangular quantum well (RQW), and (c) the experimental thermoelectric power factor enhancement rate relative to the theoretical one of conventional 2DEG $(PF_{2D/3D})_{ex} / (PF_{2D/3D})_{th}$. The unit value indicates the thermoelectric power factor enhancement of the conventional 2DEG. Credit: Yoshiaki Nakamura

Imagine stoplights and cars communicating with each other to optimize the flow of traffic. This isn't science fiction—it's the Internet of Things

(IoT), i.e., objects that sense their surroundings and respond via the internet. As the global population rises and such technologies continue to develop, you might wonder—what will power this digital world of tomorrow?

Wind, solar, yes. Something all around us might not immediately come to mind, though—heat. Now, in a study recently published in *Nature Communications*, a multi-institutional research team, including Osaka University, has unveiled a breakthrough in [clean energy](#): greatly improved thermoelectric conversion. One of its many potential applications? That's right, the IoT.

Large-scale, global integration of the IoT is limited by the lack of a suitable energy supply. Realistically, an energy supply for the IoT must be local and small-scale. Miniaturization of thermoelectric conversion can help solve this [energy-supply](#) problem by applying the otherwise wasted heat from microelectronics as a source of electricity. However, for practical applications, the efficiency of current thermoelectric-energy conversion is insufficient. Improving this efficiency was the goal of the research team's study.

"In our work, we demonstrate a two-dimensional electron gas (2DEG) system with multiple sub-bands that uses [gallium arsenide](#). The system is different from conventional methods of thermoelectric conversion," explain Yuto Uematsu and Yoshiaki Nakamura, lead and senior authors of the study. "Our system facilitates better conversion from temperature (heat) to electricity and improves the mobility of electrons in their 2D sheet. This readily benefits everyday devices like semiconductors."

Incredibly, the researchers were able to improve the power factor of thermoelectric conversion by a factor of 4 compared with conventional 2DEG systems. Other technologies, like resonant scattering, have not been as efficient for [thermoelectric conversion](#).

The team's findings could open the way to a sustainable power source for the IoT. Thin thermoelectric films on substrates made of gallium arsenide would be suitable for IoT applications. For example, these could power environmental monitoring systems in [remote locations](#) or wearable devices for medical monitoring.

"We're excited because we have expanded upon the principles of a process that is crucial to clean energy and the development of a sustainable IoT," says Yoshiaki Nakamura, senior author. "What's more, our methodology can be applied to any element-based material; the practical applications are far-reaching."

This work is an important step forward in maximizing the utility of thermoelectric power generation in modern microelectronics and is especially suitable for the IoT. As the results are not limited to gallium arsenide, further advancements to the system are possible, with sustainability and the IoT potentially benefitting greatly.

More information: Anomalous enhancement of thermoelectric power factor in multiple two-dimensional electron gas system, *Nature Communications* (2024). [DOI: 10.1038/s41467-023-44165-3](https://doi.org/10.1038/s41467-023-44165-3)

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