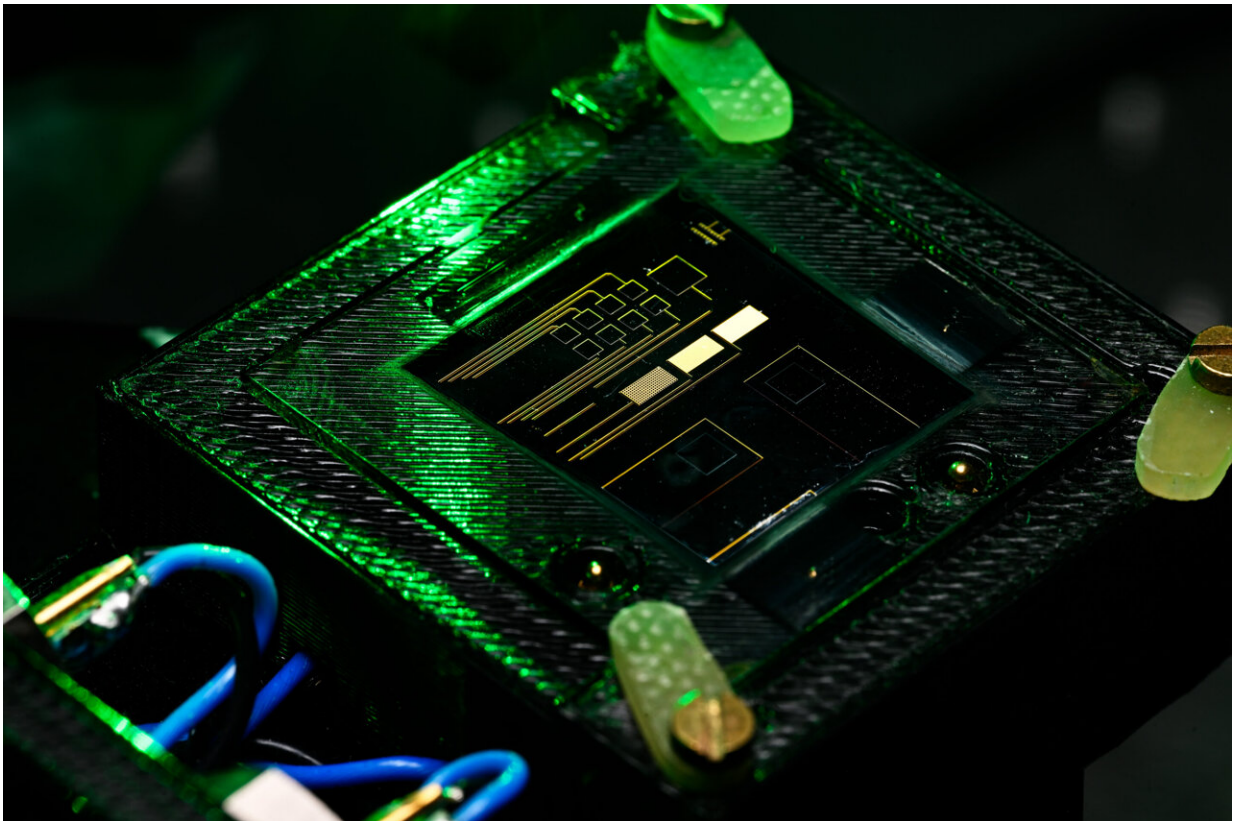


# This 'Harry Potter' light sensor achieves magically high efficiency of 200%

February 17 2023

---



Details of the photodiode used in the experimental setting. Credit: TU/e, Bart van Overbeeke

Using green light and a double-layered cell, Ph.D. researcher Riccardo Ollearo has come up with a photodiode that has sensitivity that many can

only dream of.

Solar panels with multiple stacked cells are currently breaking records. Remarkably, a team of researchers from Eindhoven University of Technology and TNO at Holst Center have now managed to make photodiodes—based on a similar technology—with a photoelectron yield of more than 200%. You would think that efficiencies of more than 100% are only possible using alchemy and other Harry Potter–like wizardry. But it can be done. The answer lies in the magical world of quantum efficiency and stacked solar cells.

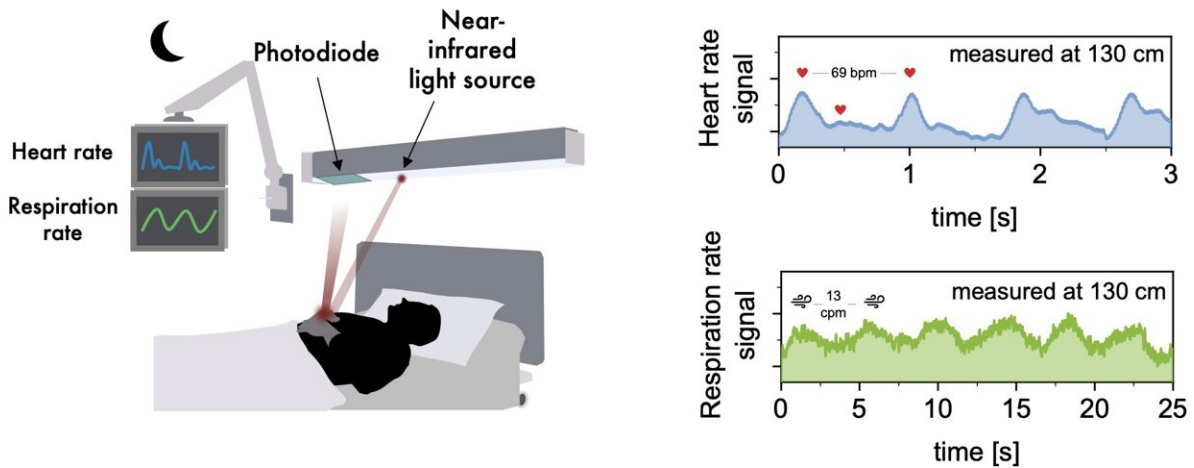
René Janssen, professor at the Eindhoven University of Technology and co-author of a new *Science Advances* paper, explains. "I know, this sounds incredible. But, we're not talking about normal energy efficiency here. What counts in the world of photodiodes is quantum efficiency. Instead of the total amount of solar energy, it counts the number of photons that the diode converts into electrons.

"I always compare it to the days when we still had guilders and lira. If a tourist from the Netherlands received only 100 lira for their 100 guilders during their holiday in Italy, they might have felt a bit shortchanged. But because in quantum terms, every guilder counts as one lira, they still achieved an efficiency of 100%. This also holds for photodiodes: the better the diode is able to detect weak light signals, the higher its efficiency."

## Dark current

Photodiodes are light-sensitive semiconductor devices that produce a current when they absorb photons from a [light source](#). They are used as sensors in a variety of applications, including medical purposes, wearable monitoring, light communication, surveillance systems, and machine vision. In all these domains, high sensitivity is key.

For a photodiode to work correctly, it has to meet two conditions. First, it should minimize the current that is generated in the absence of light, the so-called dark current. The less dark current, the more sensitive the diode. Second, it should be able to distinguish the level of background light (the "noise") from the relevant infrared light. Unfortunately, these two things usually do not go together.



In the left image we see the set-up in which the new tandem photodiode can be used to monitor the heart and respiration rates of a person. The right images show the detected heart and respiration signals recorded with the photodiode at a distance of 130 cm. Credit: TU/e, Riccardo Ollearo

## Tandem

Four years ago, Riccardo Ollearo, one of Janssen's Ph.D. students and lead author of the paper, set about solving this conundrum. In his research he joined forces with the photodetector team working at Holst Center, a research institute specialized in wireless and printed sensor technologies, Ollearo built a so-called tandem diode, a device that

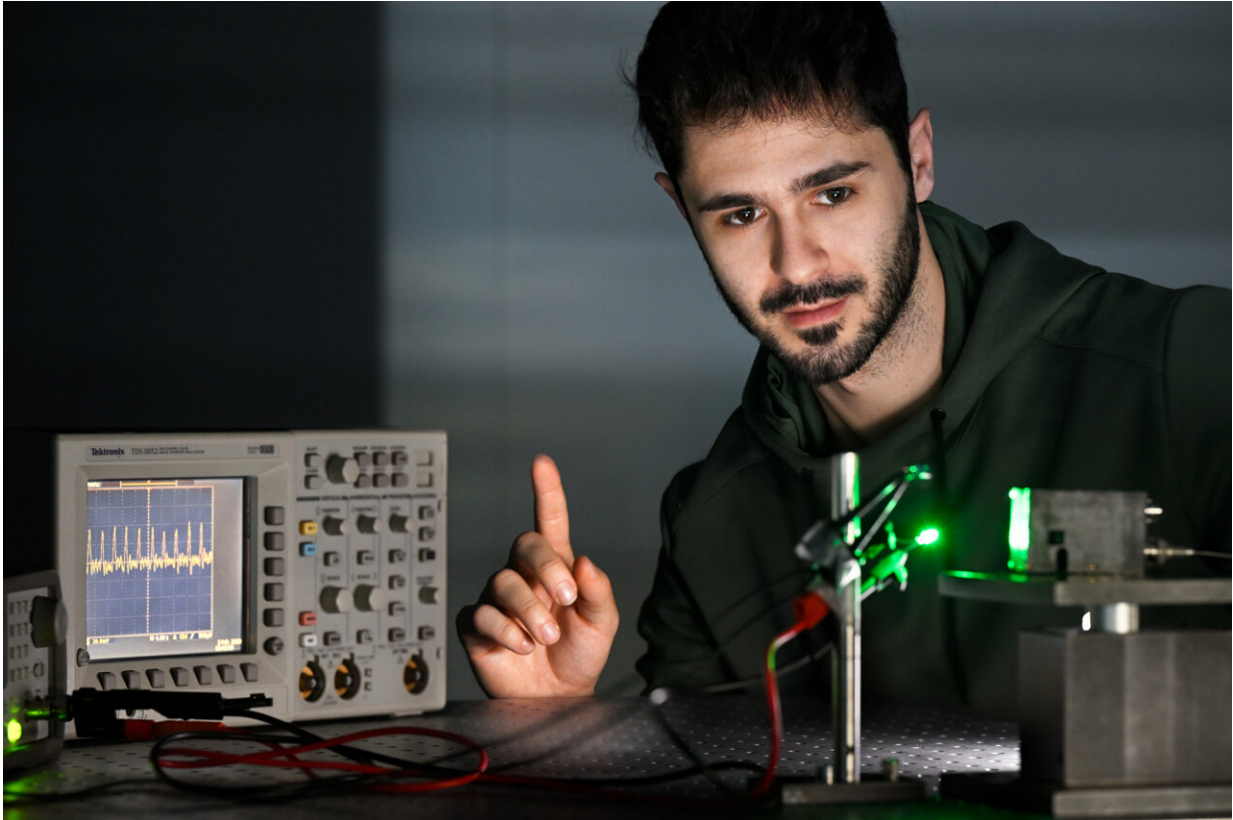
combines both perovskite and organic PV cells.

Combining these two layers—a technique also increasingly used in state-of-the-art solar cells—he was able to optimize both conditions, reaching an efficiency of 70%.

"Impressive, but not enough," says the ambitious young researcher from Italy. "I decided to see if I could increase the efficiency even further with the help of green light. I knew from earlier research that illuminating [solar cells](#) with additional light can modify their quantum efficiency, and in some cases enhance it. To my surprise, this worked even better than expected in improving the photodiode sensitivity. We were able to increase the efficiency for near-infrared light to over 200%."

Up this point, the researchers still don't know exactly how this works, although they've come up with a theory that might explain the effect.

"We think that the additional [green light](#) leads to a build-up of electrons in the perovskite layer. This acts as a reservoir of charges that is released when infrared photons are absorbed in the organic layer," says Ollearo. "In other words, every infrared photon that gets through and is converted in an electron, gets company from a bonus electron, leading to an efficiency of 200% or more. Think of it as getting two lira for your guilder, instead of one."



Holding the photodiode device at 130 cm from his finger, researcher Riccardo Ollearo was able to detect minute changes in the amount of infrared light that was reflected back into the diode. These changes turn out to be a correct indication of a person's heart rate. Credit: TU/e, Bart van Overbeeke

### **Putting the diode to the test**

The researcher tested the photodiode, which is hundred times as thin as a sheet of newsprint, and suitable for use in flexible devices, in the lab.

"We wanted to see whether the device could pick up subtle signals, such as the heart or respiration rate of a human being in an environment with realistic background light. We opted for an indoor scenario, during a sunny day with the curtains partially closed. And it worked!"



Holding the device at 130 cm from a finger, the researchers were able to detect minute changes in the amount of infrared light that was reflected back into the diode. These changes turn out to be a correct indication of changes in the [blood pressure](#) in a person's veins, which in turn indicate heart rate. When pointing the device at the person's chest, they were able to measure the respiration rate from light movements in the thorax.

With the publication of the paper in *Science Advances*, Ollearo's work is all but finished. He will defend his thesis research on April 21. So, does the research stop there?

"No, certainly not. We want to see if we can further improve the device, for instance by making it quicker," says Janssen. "We also want to explore whether we can clinically test the device, for instance in collaboration with the FORSEE project."

The FORSEE project, led by TU/e researcher Sveta Zinger and in collaboration with the Catharina Hospital in Eindhoven, is [developing an intelligent camera](#) that can observe a patient's heart and respiration rates.

**More information:** Riccardo Ollearo et al, Vitality surveillance at distance using thin-film tandem-like narrowband near-infrared photodiodes with light-enhanced responsivity, *Science Advances* (2023). [DOI: 10.1126/sciadv.adf9861](https://doi.org/10.1126/sciadv.adf9861).  
[www.science.org/doi/10.1126/sciadv.adf9861](https://www.science.org/doi/10.1126/sciadv.adf9861)

Provided by Eindhoven University of Technology

Citation: This 'Harry Potter' light sensor achieves magically high efficiency of 200% (2023, February 17) retrieved 5 May 2024 from <https://techxplore.com/news/2023-02-harry-potter-sensor-magically-high.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.