# Color sensors based on wavelength-dependent bipolar photodetectors

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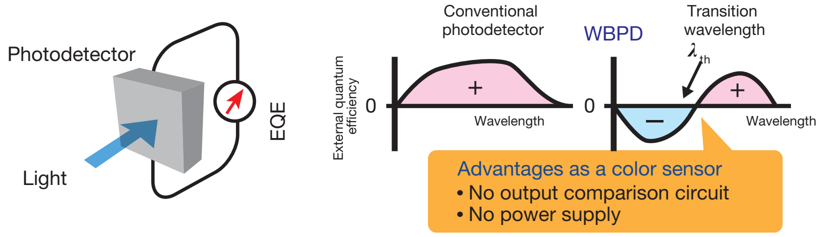
## Purpose of Research

Wavelength-dependent bipolar photodetectors (WBPDs) are attracting attention as color sensors and building blocks for optical logic circuits. Conventional WBPDs are photoelectrochemical devices mainly composed of an electrolyte and organic molecules, and suffer from the problems of having a slow response (due to their principle) and of having a transition wavelength—at which the polarity is reversed—that is limited by the optical properties of their materials. In order to overcome the problems posed by conventional technologies, this research aims to improve response speed and control the transition wavelength by using an inorganic semiconductor.

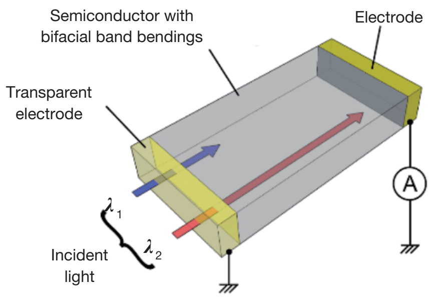
## Summary of Research

Through precise control of surface band bending of a general inorganic semiconductor material, our device is given characteristics whereby the output polarity changes depending on the wavelength of incident light. For example, a positive current is output when red light is detected, and a negative current when blue light is detected. The advantages of the device are that it can respond faster than conventional devices and can be seamlessly tuned to detect different colors by changing the size of the semiconductor.

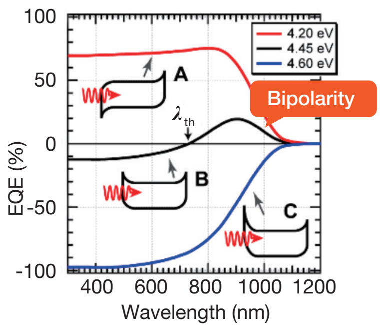
**Comparison between a conventional photodetector and WBPD**




**Schematic illustration of device developed in this research**




**Simulation results**




## Comparison with Conventional or Competitive Technology

- Successfully increases response speed—which is a problem with conventional devices—by more than 100 times.
- Our device can be seamlessly tuned to detect different colors by changing the size of the semiconductor, while conventional devices can detect only limited colors.

## Expected Applications

- Discrimination of traffic light colors for self-driving cars
- Discrimination of product colors for production lines
- Building blocks of optical logical circuits

## Challenges in Implementation

We have already completed proposal of the device's principle, execution of operation simulations and development of prototype components. We need to establish an integration technology in order to enable practical use.

## What We Expect from Companies

We require partners who will work with us to develop various applications.

**Points**

- **Output polarity changes depending on wavelength of incident light**
- **Ability to control the transition wavelength at which polarity is reversed**
- **Quick response (tens to hundreds of microseconds or less)**

## Future Developments

March 2018: Achievement of color sensor arrays

March 2019: Creation of prototypes suitable for applications

- Awards: Poster Award from the Japan Society of Applied Physics (JSAP Autumn Meeting, 2016) and other awards
- Prototype: Available