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 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.

**Future Developments**

March 2018: Achievement of color sensor arrays
March 2019: Creation of prototypes suitable for 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)

**Comparison between a conventional photodetector and WBPD**

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>EQE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>40</td>
</tr>
<tr>
<td>600</td>
<td>60</td>
</tr>
<tr>
<td>800</td>
<td>80</td>
</tr>
<tr>
<td>1000</td>
<td>100</td>
</tr>
</tbody>
</table>

**Wavelength-dependent Bipolarity**

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Bipolarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>+</td>
</tr>
<tr>
<td>Blue</td>
<td>-</td>
</tr>
</tbody>
</table>

**Advantages as a color sensor**

- No output comparison circuit
- No power supply

**Awards**

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