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VII Semester

AU3008 Sensors and Actuators

UNIT – 3 - Variable and Other Special Sensors

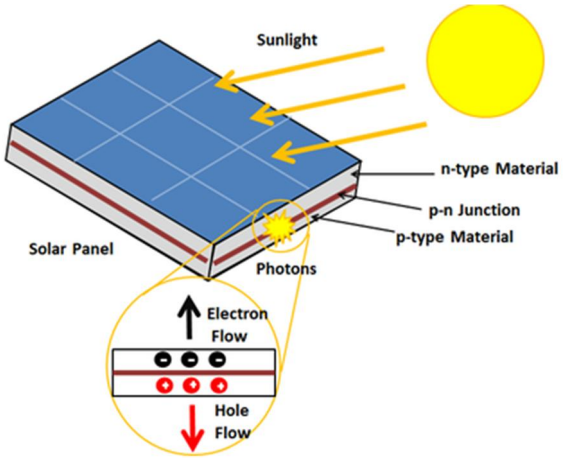
3.11 Solar, Light sensor, Antiglare Sensor

3.11.1 Solar Sensor / Light Sensors

- **Solar sensors** are devices that detect and measure solar radiation, often in the form of light intensity. They play a crucial role in various applications, from controlling automated systems to monitoring solar energy production.

- **Types of Solar Sensors**

1. **Photovoltaic Cells:**
   - Directly convert sunlight into electrical energy.
   - Used in solar panels for energy generation.
   - Can also be used as sensors to measure light intensity.
   - The **photovoltaic effect** is a process that generates voltage or electric current in a photovoltaic cell when it is exposed to sunlight.



Components:

- **n-type Material:** This layer has an excess of electrons, making it negatively charged.
- **p-type Material:** This layer has a deficiency of electrons, resulting in positively charged "holes".
- **p-n Junction:** This is the interface between the n-type and p-type materials.

Process:

1. **Sunlight Absorption:** Photons (particles of light) from sunlight strike the solar cell.
2. **Electron Excitation:** The energy from the photons excites electrons in the atoms of the semiconductor material.
3. **Electron-Hole Pair Generation:** This excitation causes electrons to break free from their atoms, leaving behind positively charged "holes".
4. **Electron Flow:** The electrons, now free, move towards the n-type side of the junction, creating a flow of electrons.
5. **Hole Flow:** The "holes" (absence of electrons) move towards the p-type side, creating a flow of positive charge.
6. **Electric Current:** This movement of electrons and holes creates an electric current.
7. **Electrical Output:** The electric current is collected by electrodes on the surface of the solar cell and can be used to power devices or stored in batteries.

Key Points:

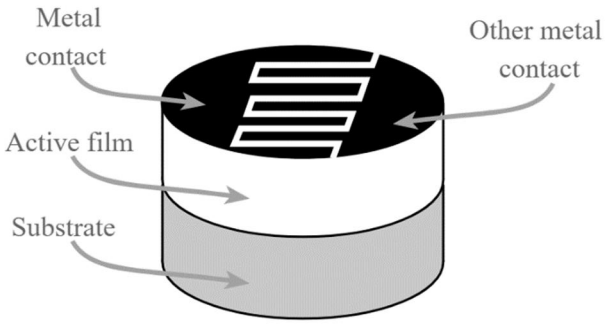
- **Photovoltaic Effect:** The process of converting sunlight into electricity is known as the photovoltaic effect.
- **Direct Current (DC) Output:** Solar cells produce direct current (DC) electricity.
- **Efficiency:** The efficiency of solar cells, or how much of the sunlight they convert into electricity, varies depending on the materials and design.
- **Solar Panels:** Multiple solar cells connected together form a solar panel, which can generate larger amounts of electricity.

2. **<u>Photoresistors (LDRs):</u>**
    - ❖ Change their electrical resistance based on the intensity of light falling on them.

- ❖ Simple and inexpensive, often used in basic light-sensing applications.

❒ A light-dependent resistor (LDR) is a passive component that changes its resistance based on light intensity. Also known as photoresistors, photocells, or photoconductors,

❒ LDRs are made from semiconductor materials with high resistance in darkness and low resistance in light. They are commonly used as light sensors in street lighting, alarm clocks, burglar alarms, and light meters.



❒ **Components:**

❖ **Active Film:** This is a thin layer of semiconductor material, typically cadmium sulfide (CdS). It's the part that is sensitive to light.

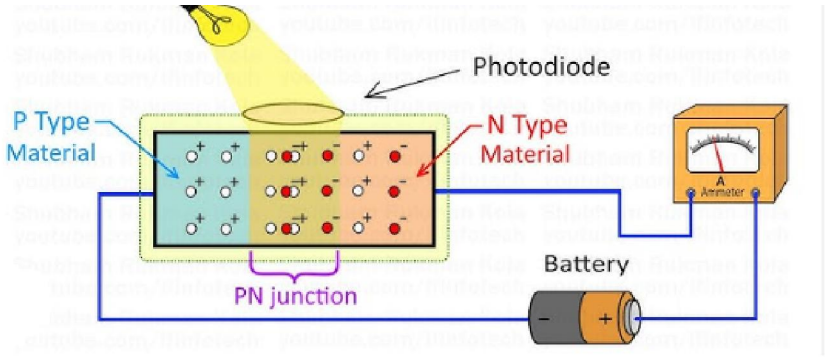
❖ **Metal Contacts:** These are two metal electrodes that are attached to the active film. They are used to connect the photoresistor to an external circuit.

❖ **Substrate:** This is the base material on which the active film and metal contacts are deposited. It's usually a ceramic or glass material.

❒ **Working:**

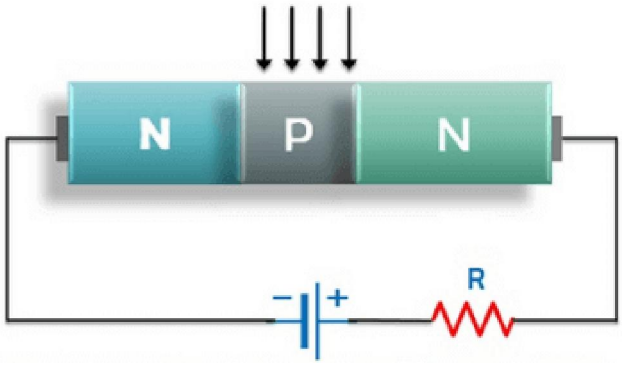
1. **Light Absorption:** When light falls on the active film, it absorbs photons (particles of light).
2. **Electron Excitation:** The absorbed photons excite electrons in the semiconductor material, freeing them from their atoms.
3. **Increased Conductivity:** These free electrons increase the conductivity of the semiconductor material.
4. **Resistance Decrease:** As the conductivity increases, the electrical resistance of the photoresistor decreases.

3. **Photodiodes:**
   - ❖ Convert light energy into electrical current.
   - ❖ More sensitive and precise than photoresistors.
   - ❖ Used in various applications, including light meters and solar energy systems.



- ❖ A photodiode is a type of semiconductor diode that converts light energy into electrical energy.
- ❖ It consists of a p-n junction, similar to a regular diode, but it is designed to be exposed to light.
- ❖ In this configuration, the positive terminal of the battery is connected to the n-type side of the photodiode, and the negative terminal is connected to the p-type side.
- ❖ This creates a depletion region at the p-n junction, which is wider than in forward bias.
- ❖ The depletion region acts as a barrier to the flow of current in the absence of light.

4. **Phototransistors:**



- ❖ Similar to photodiodes but amplify the current generated by light.
- ❖ Often used in automatic lighting control systems and security systems

❖ **Components:**

- ✓ **Collector:** The collector is the region where the majority carriers (electrons in an NPN transistor) are collected.
- ✓ **Base:** The base is a thin, lightly doped region that controls the flow of current between the collector and the emitter.
- ✓ **Emitter:** The emitter is the region that emits majority carriers.
- ✓ **Light-Sensitive Region:** This is a region of the transistor that is sensitive to light. When light falls on this region, it generates electron-hole pairs, which can be collected by the collector and base.

❖ **Working Principle:**

- ✓ **Light Absorption:** When light falls on the light-sensitive region, photons are absorbed, generating electron-hole pairs.
- ✓ **Electron-Hole Separation:** The electric field in the depletion region separates the electron-hole pairs.
- ✓ **Current Amplification:** The electrons generated by the light are injected into the base region. This small current in the base controls a larger current flowing from the collector to the emitter.
- ✓ **Output Current:** The output current from the collector is amplified compared to the current generated by the light.

3.11.2 Antiglare Sensor:

❒ An **anti-glare sensor** is a type of light sensor designed to detect and mitigate glare, usually in applications involving displays, automotive lighting, or optical systems. These sensors help improve visibility, comfort, and safety by reducing the effects of excessive brightness or reflected light.

Key Features of Anti-Glare Sensors:

1. **Light Intensity Detection**:
   - ❒ Measures the brightness of ambient light or direct glare sources.
   - ❒ Typically detects visible light but may also monitor specific wavelengths (e.g., infrared for automotive applications).
2. **Glare Recognition**:

- ❒ Identifies high-intensity light sources that cause glare.
- ❒ Distinguishes between useful light and disruptive glare.

3. **Adaptive Adjustment**:
   - ❒ Automatically adjusts brightness or applies filtering to counteract glare.
   - ❒ Common in displays and automotive systems (e.g., adaptive headlights or rearview mirrors).

Technologies Used in Anti-Glare Sensors:

1. **Ambient Light Sensors**:
   - ❖ Measure overall brightness and adjust illumination or display settings.
   - ❖ Example: Sensors like **BH1750** or **TSL2591**.
2. **Polarized Light Sensors**:
   - ❖ Detect the polarization of reflected light to identify glare sources.
   - ❖ Used in advanced automotive and optical systems.
3. **Infrared Sensors**:
   - ❖ Identify high-intensity IR sources, often used in conjunction with visible light sensors for enhanced glare detection.
4. **Image Processing Cameras**:
   - ❖ In high-end systems, cameras paired with image processing algorithms identify glare sources and adjust optical elements accordingly.

Examples of Anti-Glare Systems

1. **Automotive Rearview Mirrors**:
   - ❖ Equipped with light sensors to detect glare from headlights.
   - ❖ Example: Gentex auto-dimming mirrors.
2. **Adaptive Displays**:
   - ❖ Smartphones like Apple iPhones and Samsung Galaxy devices use ambient light sensors to adjust brightness and color temperature.
3. **Smart Windows**:
   - ❖ Electrochromic windows that adjust tint based on glare detection.

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