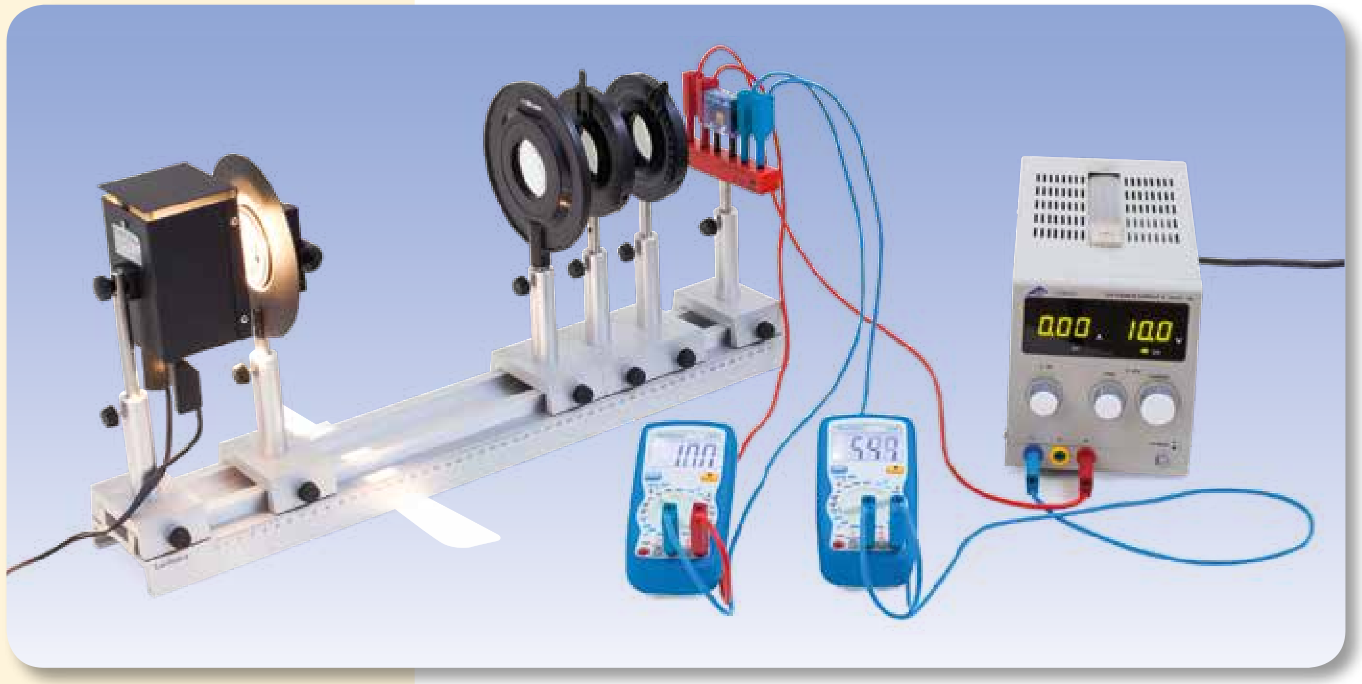
PHOTOCONDUCTIVITY



EXPERIMENT PROCEDURE

- **Measure current as a function of voltage for various intensities of light.**
- **Measure current as a function of light intensity for various voltages.**

OBJECTIVE

Record the characteristic curve for a photoresistor

SUMMARY

Photoconductivity utilises absorption of light by means of the inherent photoelectric effect in a semiconductor to create electron-hole pairs. One specific semiconductor mix which exhibits the photoelectric effect particularly strongly is cadmium sulphide. This material is used in the construction of photoresistors. In this experiment, a CdS photoresistor is illuminated with white light from an incandescent bulb. The intensity of this illumination of the photoresistor is then varied by crossing two polarising filters placed one behind the other in the beam.

REQUIRED APPARATUS

Quantity	Description	Number
1	Optical Bench U, 600 mm	1003040
6	Optical Rider U, 75 mm	1003041
1	Experimental Lamp, Halogen	1003038
1	Adjustable Slit on Stem	1000856
1	Convex Lens on Stem f =+150 mm	1003024
2	Polarisation Filter on Stem	1008668
1	Holder for Plug-in Components	1018449
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	1003312 or
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	1003311
2	Digital Multimeter P1035	1002781
3	Pair of Safety Experimental Leads, 75 cm, red/blue	1017718

You can find technical information about the equipment at 3bscientific.com

BASIC PRINCIPLES

Photoconductivity utilises absorption of light by means of the photoelectric effect in a semiconductor to create electron-hole pairs. In some semiconductors, this effect is dominated by boundaries of discontinuities in the material. The effect is then not only dependent on the basic material, but also on its microstructure and on impurities. Ionisation of these impurities acts in a similar way to doping for a few milliseconds, increasing the electrical conductivity of the material. One specific semiconductor mix which exhibits the inherent photoelectric effect particularly strongly is cadmium sulphide, which is used to make photoresistors.

Absorption increases the conductivity of the semiconductor in a manner described by the following equation:

(1) $$\Delta\sigma = \Delta p \cdot e \cdot \mu_p + \Delta n \cdot e \cdot \mu_n .$$

e: Elementary charge,
Δn: Change in electron concentration, Δp: Change in hole concentration,
μ_n: Electron mobility, μ_p: Hole mobility

When a voltage U is applied, the photoelectric current is given by the following:

(2) $$I_{Ph} = U \cdot \Delta\sigma \cdot \frac{A}{d} .$$

A: Cross-section of current path,
d: Length of current path

The semiconductor therefore acts in a circuit like a light-dependent resistor, the value of its resistance decreasing when light shines upon it. The dependence of current on light intensity Φ at a constant voltage may be expressed in the form

(3) $$I_{Ph} = a \cdot \Phi^{\gamma} \text{ where } \gamma \le 1 .$$

Here the value γ is indicative of the recombining processes within the semiconductor material.
In this experiment, a CdS photoresistor is illuminated with white light from an incandescent bulb. Measurements are made of how current I through a CdS photoresistor depends on the applied voltage U at constant light intensity Φ and how it depends on intensity Φ at constant voltage U. The intensity is varied by crossing two polarising filters placed one behind the other in the light beam.
If the maximum power dissipation of 0.2 W is exceeded, the photoresistor will be damaged. For this reason the intensity of the incident light in the experiment is limited by means of an adjustable slit directly behind the light source.

EVALUATION

The current-voltage characteristics of a CdS photoresistor are along a straight line through the origin, as implied by equation (2).
In order to describe the characteristics for current and light intensity, the term $\cos^2\alpha$ is calculated for use as a relative measure of light intensity. In this case, α is the angle between the directions of polarisation of the two filters. However, even when they are fully crossed, the filters will not block all the light. Also, it is not possible to avoid entirely the intrusion of residual light from the room in which the experiment is taking place. Under such circumstances, equation (3) needs to be modified to

$$I = a \cdot \Phi^{\gamma} + b \text{ with } \gamma \le 1 .$$

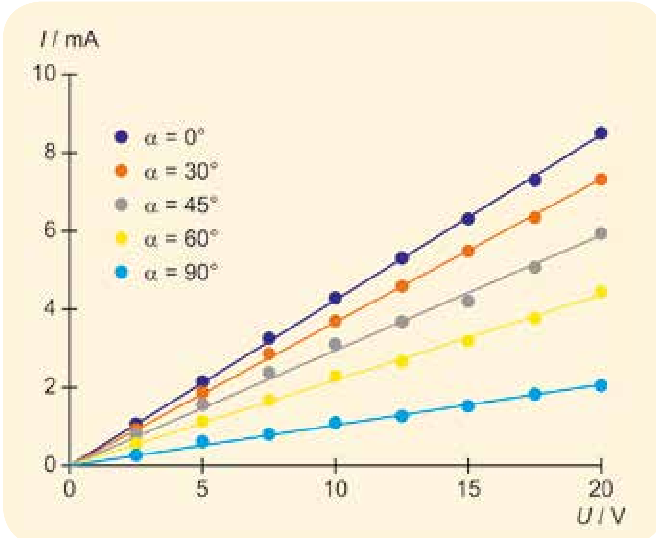


Fig. 1: Current-voltage characteristics of a CdS photoresistor for various intensities of light.

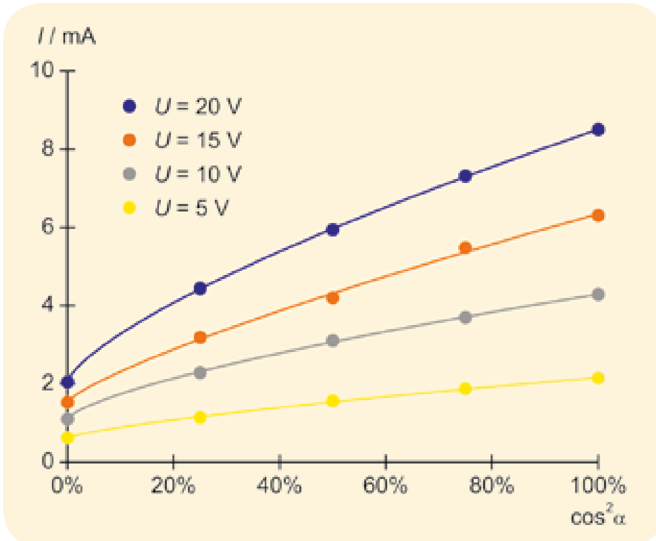


Fig. 2: Characteristics for current and light intensity of a CdS photoresistor at various voltages.