Recording the current-voltage characteristics of light-emitting diodes (LED)

Object of the experiment

- Studying the current *I* as a function of the voltage *U* for LEDs of different colours.

Principles

Virtually all aspects of electronic circuit technology rely on semiconductor components. The semiconductor diodes are among the simplest of these. They consist of a semiconductor crystal in which an n-conducting zone is adjacent to a p-conducting zone. Capture of the charge carriers, i.e. the electrons in the n-conducting and the "holes" in the p-conducting zones, forms a zone of low-conductivity at the junction called the depletion layer. The size of this zone is increased when electrons or holes are pulled out of the depletion layer by an external electric field with a certain orientation. The direction of this electric field is called the reverse direction. Reversing the electric field into forward direction drives the respective charge carriers into the depletion layer, allowing current to flow through the diode.

The experiment compares the characteristics of infrared, red, yellow and green light-emitting diodes. The threshold voltage *U* is inserted in the formula

$$e \cdot U_S = h \cdot \frac{c}{\lambda}$$

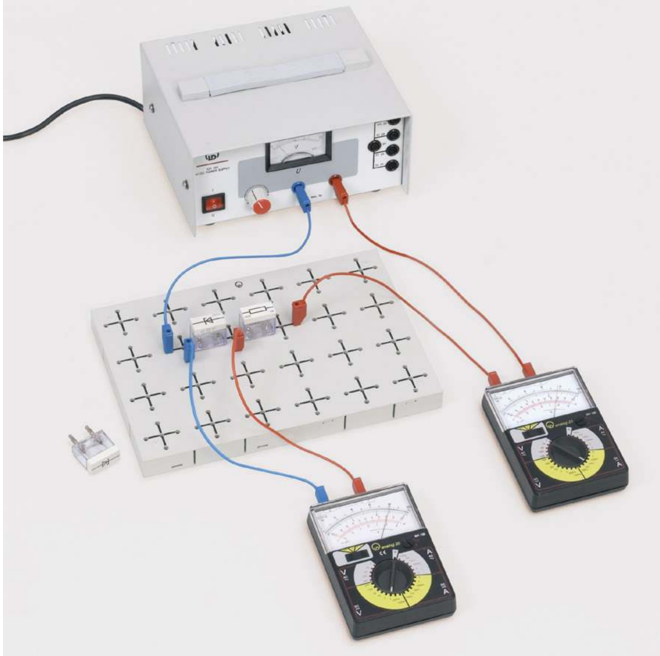
(with *e*: electron charge; *c*: velocity of light; *h*: Planck's constant)

to estimate the wavelength λ of the emitted light.

Apparatus

1 Rastered socket panel DIN A 4	576 74
1 STE Resistor 100 Ω, 2 W	577 32
1 LED, green, top	578 57
1 LED, yellow, top	578 47
1 LED, red, top	578 48
1 LED infrared, lateral	578 49
1 AC/DC Power supply 0...12 V / 3 A	521 485
2 Multimeters LDanalog 20	531 120
1 Connecting Lead 100 cm Red	500 441
2 Pair cables 50 cm, red/blue	501 45

Setup



Carrying out the experiment

- Set up the experiment as shown in the figure. Plug in the green LED, the tip of the triangle pointing from plus to minus (in current direction). Pay attention of the measuring range and polarity of the multimeters.
- Record the characteristic: Carefully increase voltage *U* – starting with 0 V – and observe current *I*. The current *I* should not exceed 30 mA.
- For different pairs of voltage *U* and current *I* fill in the first two columns of table .
- Repeat the experiment with the other LEDs and fill in the remaining columns of the table.

KEM 0806

LD Didactic GmbH · Leyboldstrasse 1 · D-50354 Hürth · Phone: (02233) 604-0 · Fax: (02233) 604-222 · e-mail: info@ld-didactic.de

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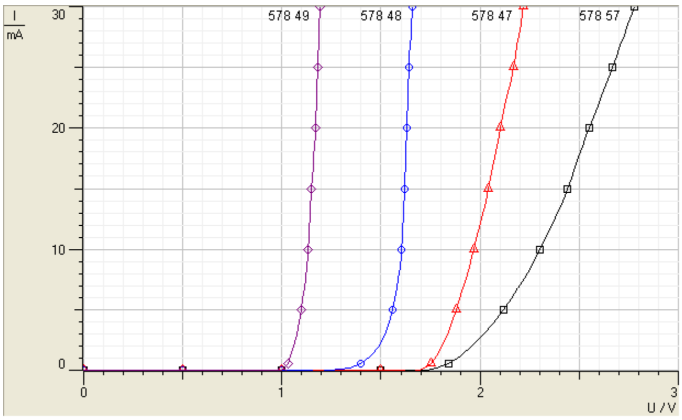
Measuring example

Table : Light emitting diodes in conducting-state direction

green 578 57		yellow 578 47		red 578 48		infrared 578 49	
$\frac{U}{V}$	$\frac{I}{mA}$	$\frac{U}{V}$	$\frac{I}{mA}$	$\frac{U}{V}$	$\frac{I}{mA}$	$\frac{U}{V}$	$\frac{I}{mA}$
0	0	0	0	0	0	0	0
0.5	0	0.5	0	0.5	0	0.5	0
1.0	0	1.0	0	1.0	0	1.0	0
1.5	0	1.5	0	1.40	0.5	1.03	0.5
1.84	0.5	1.75	0.5	1.56	5	1.10	5
2.12	5	1.88	5	1.60	10	1.13	10
2.30	10	1.97	10	1.61	15	1.15	15
2.43	15	2.03	15	1.63	20	1.16	20
2.57	20	2.10	20	1.64	25	1.18	25
2.67	25	2.17	25	1.66	30	1.19	30
2.78	30	2.22	30				

Evaluation and results



LEDs are acting like a normal diode.

The threshold-voltage depends on the colour of the emitted light. Choosing a LED with smaller wavelength, i.e. higher frequency of the emitted light results in a higher threshold voltage.

Cat. No.	Colour	Threshold voltage $\frac{U_S}{V}$	Wave-lenght $\frac{\lambda}{nm}$
578 57	green (appr. 500…580 nm)	2.1	590
578 47	yellow (appr. 590 nm)	1.9	650
578 48	red (appr. 600…800 nm)	1.6	780
578 49	Infrared (> 800 nm)	1.1	1100

The wavelength of the emitted light of a LED can be roughly approximated by inserting the measured value of the threshold voltage in the above mentioned formula. The emitted wave-length is always a bit shorter than the calculated one, due to the thermal energy of the charge carriers.

With modern LEDs, specifically green/blue ones based on GaN, it is possible that photons are emitted from deeper levels. In this case, the wavelength is smaller then it would be expected from the threshold voltage

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