Examination

Material Characterization - Optical Spectroscopy (Dr. Baur & Prof. Dr. Jüstel)

Date: March 14th, 2019 **Max. 50 points**

Name, given name:

Enrolment number:

Please only use these sheets (you may also use the back of the sheets)!

Do not use a pencil!

Task 1) **10 points**

Basics of optical spectroscopy

a) What kind of radiation sources (more than one might be required) can be used for the following measurement purposes? (1 point each)

- Absorption spectrum between 150 and 1000 nm
- Emission spectrum between 500 and 800 nm under 450 nm excitation
- Excitation spectrum between 150 and 700 nm
- Decay curve for a phosphor with a decay time in the nanosecond range
- Decay curve for a phosphor with a decay time in the millisecond range

b) Why is a grating often required for optical spectroscopy? (2 points)

c) You want to record an emission spectrum in the range from 400 to 800 nm under 300 nm excitation using a grating-type monochromator. This measurement will require a long pass filter. Why is it necessary and which filter could you use (specify the cutoff wavelength of the filter)? (3 points)

Task 2) **10 points**

Luminescence spectroscopy

a) Sketch a typical fluorescence spectrometer and give a short (1-2 sentences each) description of each component. (3 points)

b) Describe how the emission spectrum of a luminescent powder that can be excited at 450 nm, e.g. $CaAlSiN_3:Eu^{3+}$, can be recorded. (2 points)

c) Describe how the excitation spectrum of a luminescent powder that shows emission at 650 nm, e.g. $CaAlSiN_3:Eu^{3+}$, can be recorded. (2 points)

d) Why is it usually necessary to correct an <u>excitation</u> spectrum? Describe a method to perform that correction. (3 points)

Task 3) **10 points**

Absorption and reflection spectroscopy

$Y_3Al_5O_{12}$ (YAG) is a garnet-type compound, which is widely used both as a single crystal and in the form of micro-scale powder.

a) Describe how the transmission of a YAG single crystal in the wavelength range from 150 to 1000 nm can be measured and sketch the measurement setup. (3 points)

b) Describe how you can determine the absorption of a micro-scale powder (3 points)

c) Describe with the help of the Kubelka-Munk-Function whether completely white or completely black materials can exist. (2 points)

Kubelka-Munk-Function: $$\frac{A}{S} = \frac{(1-R_\infty)^2}{2R_\infty}$$

d) Name two materials that can be used for reflection measurements in the wavelength range from 250 to 800 nm. (2 points)

Task 4) **10 points**

Temperature-dependent spectroscopy

a) Describe how a thermal quenching curve at temperatures from 100 to 500 K is recorded. (3 points)

b) Sketch a typical thermal quenching curve and mark the $T_{1/2}$ temperature. What is the meaning of that temperature? (2 points)

c) The Struck-Fonger equation is used to fit a thermal quenching curve. The parameter ΔE is an important result of the fit. What is the meaning of that parameter? How can $T_{1/2}$ be calculated from it? (3 points)

Struck-Fonger equation: $$I(T) = \frac{I_0}{1 + B * e^{-\frac{\Delta E}{kT}}}$$

d) Is the thermal quenching process reversible or irreversible? Give a short explanation for your choice. (2 points)

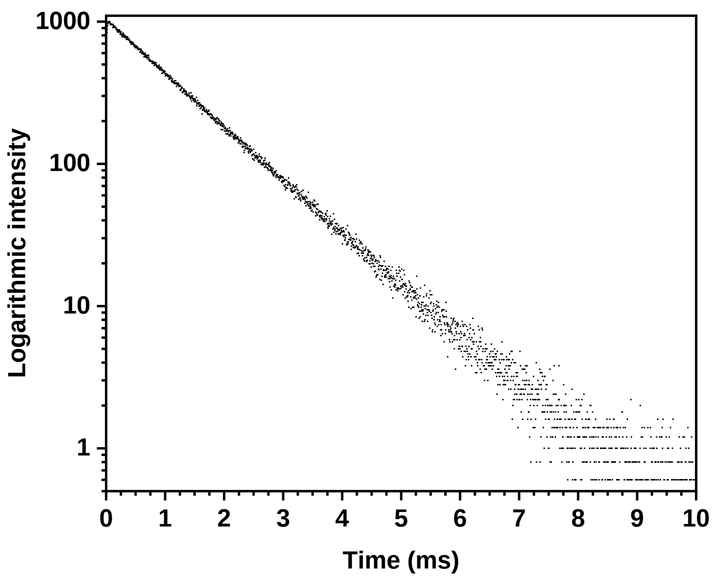
Task 5) **10 points**

Time-resolved spectroscopy

a) Describe how the decay curve of a luminescent material can be recorded. Which radiation source can be used for a luminescent material with a decay time in the millisecond range? (4 points)

b) Name two reasons why the decay curve can deviate from linearity on a logarithmic intensity scale. (2 points)

c) The figure below shows the decay curve of the red Eu^{3+} emission (620 nm) of $K_4(UO_2)Eu_2(Ge_2O_7)_2$. Please determine the $\tau_{1/10}$ and $\tau_{1/e}$ values from the curve. (2 points)



d) How is the decay time related to the internal quantum efficiency? (2 points)