Examination

“Material Characterisation – Part Optical Spectroscopy”

(Prof. Dr. Thomas Jüstel)

Date: February 3rd, 2023 **Maximum 50 Points**

Name, Given name: **Enrolment number:**

Please only use these sheets (you might also use the reverse side)!

Task 1) **(10 Points)**

Basics of Optical Spectroscopy

a) Sketch a typical spectrometer for absorption spectroscopy! (3 points)

b) Sketch a typical spectrometer for fluorescence spectroscopy! (3 points)

c) Explain why excitation spectra must be corrected! (2 points)

d) Sketch the spectrum of an ideal light source for an optical spectrometer (2 points)

Task 2) **(10 Points)**

Absorption and Reflection Spectroscopy

$Lu_3Al_5O_{12}$ (LuAG) is a widely applied host material for luminescent, scintillator and laser materials.

a) Describe the way to determine the absorption spectrum of a single crystals of LuAG! (2 Points)

b) Describe the way to determine the absorption spectrum of microscale powders of LuAG! (2 Points)

c) Explain why an integration sphere is required for reflection measurements of powder samples! (2 points)

d) Which physical properties are responsible for the high and low energy edge of the absorption of a window material? (2 points)

e) Clarify by means of the Kubelka-Munk function, whether perfectly white or black substances may exist! (2 Points)

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

Task 3) **(10 Points)**

Luminescence spectroscopy

a) An emission spectrum in the range from 500 to 800 nm of the red-emitting luminescent material $Y_2O_3:Eu^{3+}$ under 254 nm excitation shall be recorded. Which excitation source and sample holder is required? What is the excitation and emission monochromators doing during the measurement? Which type of correction has to be applied and why? (4 points)

b) An excitation spectrum in the range from 250 to 500 nm of the green-emitting luminescent material $Lu_3Al_5O_{12}:Ce^{3+}$, which emits at 525 nm, shall be recorded. Which excitation source and sample holder is required? What is the excitation and emission monochromators doing during the measurement? Which type of correction has to be applied and why? (4 points)

c) The intensity of emission and excitation spectra is mostly plotted against wavelength. How could you convert these to obtain spectra where the intensity is plotted against a quantity that is proportional to energy? (2 points)

Task 4) **(10 Points)**

Time resolved spectroscopy

a) Describe the procedure to record a decay curve of an arbitrary luminescent material! (2 Points)

b) Which radiation sources can be used for a luminescent material with a decay time in the millisecond or in the nanosecond range? (2 Points)

c) Name physical processes, which show zero order or first order decay behavior! (2 Points)

d) Sketch the decay curve of a zero and a first order process (choose a logarithmic y-axis)! (4 Points)

Task 5) **(10 Points)**

Temperature resolved spectroscopy

a) The Struck-Fonger equation is used to fit a thermal quenching curve obtained by temperature resolved recording of emission spectra. The parameter ΔE is an important result of the fit. What is the meaning of this parameter? How can $T_{1/2}$ be calculated from it? (3 Points)

$I(T) = A_0 + I_0/(1 + B \cdot \exp(-\Delta E/kT))$ „Struck-Fonger-Equation“

b) Sketch the shape of a typical thermal quenching curve in a temperature-intensity diagram and also assign the thermal quenching temperature $T_{1/2}$! (2 Points)

c) Describe the way to measure a thermoluminescence spectrum and sketch a glow curve in an appropriate x-y diagram (3 points)

d) Which information can be derived from such glow curve? (2 points)