Examination

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

Date: January 31st, 2019 **Max. 50 points**

Name, given name:

Enrolment number:

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

Task 1) **10 points**

Luminescence Spectroscopy

a) Sketch the construction of a typical fluorescence spectrometer, name all relevant parts and give a short(!) explanation of each part (4 points)

b) Which excitation source would you use for each of the following cases: (3 points)

- Decay measurement of Eu^{2+} (decay time of ~ 1 µs)
- Decay measurement of Eu^{3+} (decay time of ~ 1 ms)
- Excitation spectrum measurement in the range from 250 to 500 nm

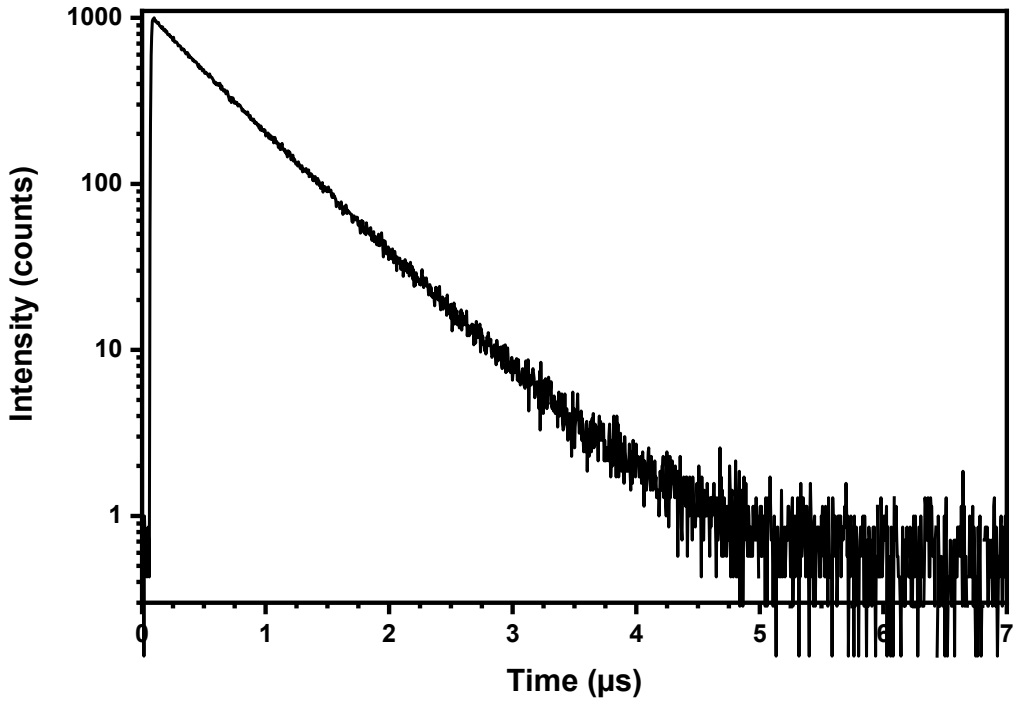
c) Why is it necessary to correct emission spectra? Please also describe how the correction data is obtained. (3 points)

Task 2) **10 points**

Time-resolved spectroscopy

a) Describe how a decay curve measurement is generally conducted. (3 points)

b) The figure below displays the decay curve of $Na_3RbMg_7(PO_4)_6:Eu^{2+}$, which is a novel blue-emitting phosphor. Please estimate the decay constants $\tau_{1/e}$ and $\tau_{1/10}$ from the following graph! Give an example of what knowledge of the decay constant can be used for (2 points)



c) The above curve has a linear part when the logarithmic intensity is plotted over time. Name two potential causes why a decay curve could deviate from linearity. (2 points)

d) Which of the following functions can be used for a physically meaningful fit of the above decay curve. Please explain for each function why it can or cannot be used: (3 points)

- $I(t) = A_0 + B * e^{-\frac{t}{\tau}}$
- $I(t) = A_0 - B * e^{-\frac{t}{\tau}}$
- $I(t) = A_0 - B_1 * e^{-\frac{t}{\tau_1}} - B_2 * e^{-\frac{t}{\tau_2}}$

Task 3) **10 points**

Temperature-resolved measurements

a) Please describe how a thermal quenching measurement is generally performed. (3 points)

b) Sketch a typical thermal quenching curve and mark the $T_{1/2}$ point. Please explain the meaning of the $T_{1/2}$ value and why it is an important property of a phosphor. (2 points)

c) Please sketch a potential thermal quenching process (e.g. intersystem crossing or photo-ionization) and explain it. Is thermal quenching a reversible or an irreversible process? (4 points)

d) Name a useful application of the thermal quenching behavior of a phosphor. (1 point)

Task 4) **10 points**

Reflection spectroscopy

a) Sketch a typical reflection spectrometer and describe a reflection measurement in broad terms (4 points)

b) Sketch the reflection spectrum (250 to 800 nm) of a

- white powder
- yellow powder
- blue powder

(2 points)

c) Why is an integration sphere required for reflection measurements? (2 points)

d) Name two possible reflection standards that could be used for a reflection measurement in the range of 250 to 800 nm and explain which material you would choose and why. (2 points)

Task 5) **10 points**

Quantum efficiency

a) Please explain the difference between external and internal quantum efficiency. One of the two is always larger than the other, which is it and why? (3 points)

b) How can you determine the internal quantum efficiency of an activator? (2 points)

c) Please describe how the external quantum efficiency can be measured directly, i.e. without a reference phosphor with a known quantum efficiency. (3 points)

d) Explain the term “light yield”. (2 points)