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Optical study of phase transitions of mixed perovskite nanocrystals $CsPb(Br_xI_{1-x})_3$ obtained in borogermanate glass

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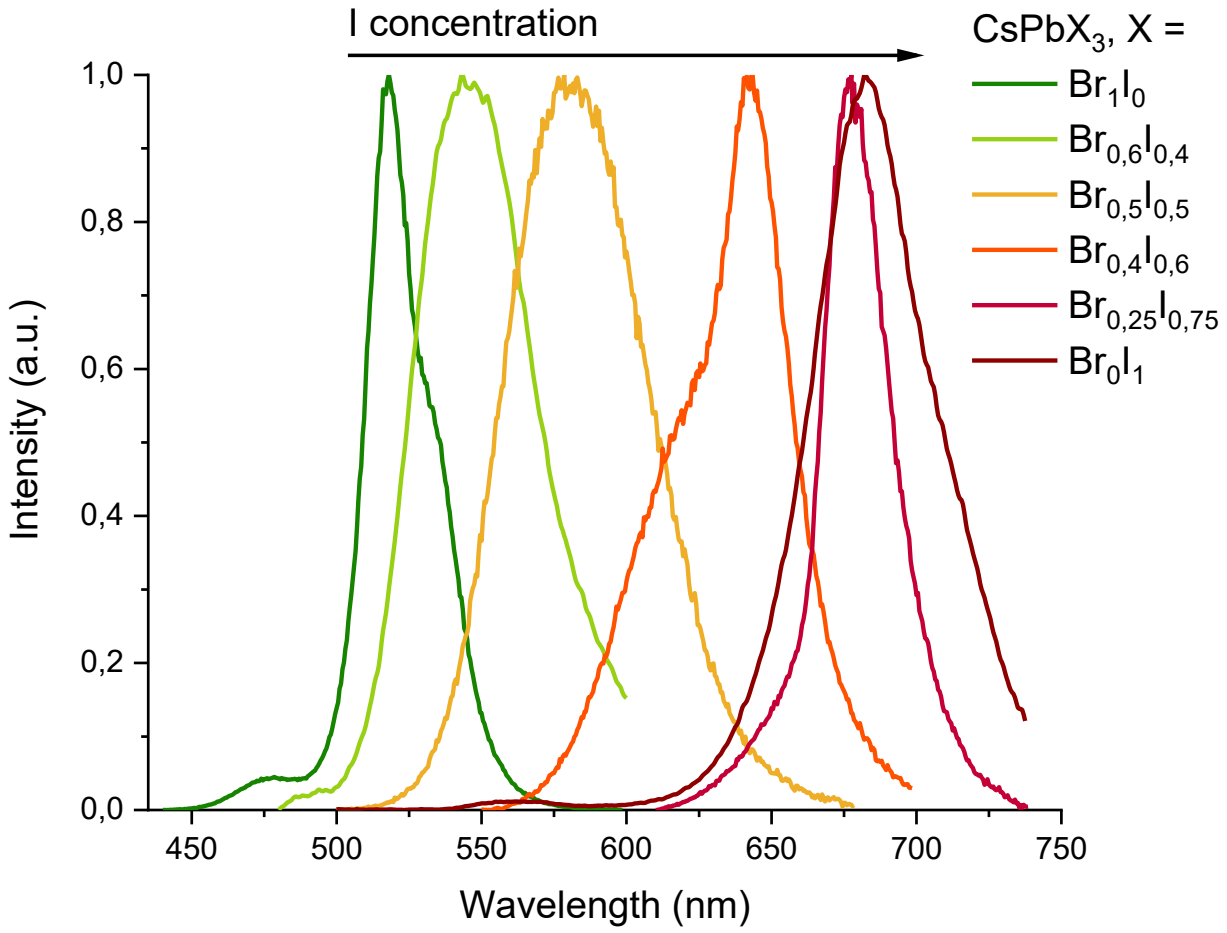
Nanocrystals $CsPbHal_3$



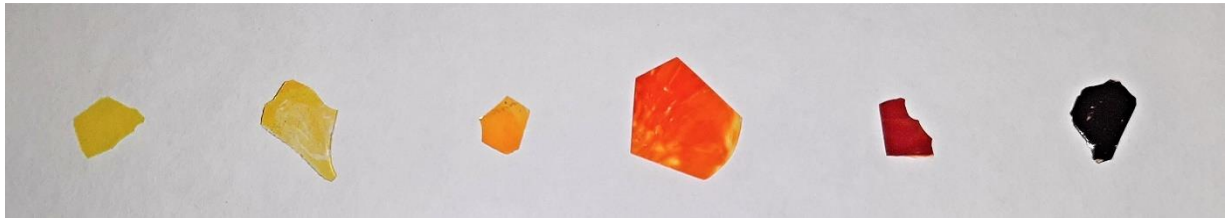
Luminescence spectra

- direct band gap semiconductors,
- high absorption and emission cross sections,
- low lasing thresholds,
- narrow luminescence bands,
- possibility to tune the luminescence throughout the entire visible spectrum

- perovskites undergo several phase transitions in the temperature range of 30 - 330 °C

Object of study

- Glass matrix
  23,59 B_2O_3 – 38,09 GeO_2 – 6,41 Na_2O – 5,03 ZnO – 1,38 P_2O_5 – 2,85 TiO_2 – 4,99 K_2O – 5,41 Cs_2O – 2,26 PbO – 9,98*x* Br – 9,98(1-*x*) I mol.%
- *x* = 1; 0,6; 0,5; 0,4; 0,25; 1
- Nanocrystals $CsPb(Br_xI_{1-x})_3$ nucleated during the annealing
- Glass synthesis
  30 min, 950 °C
- T_g = 440 – 450 °C

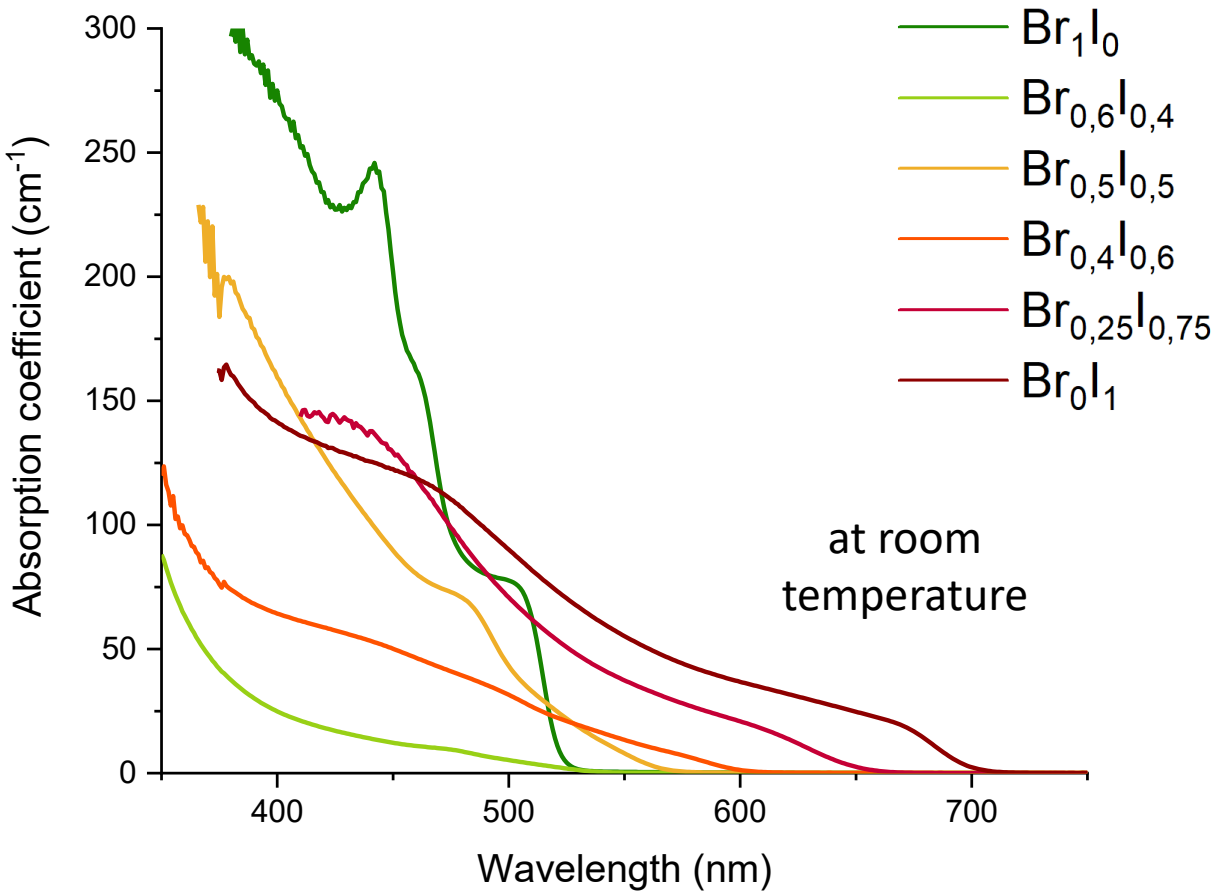


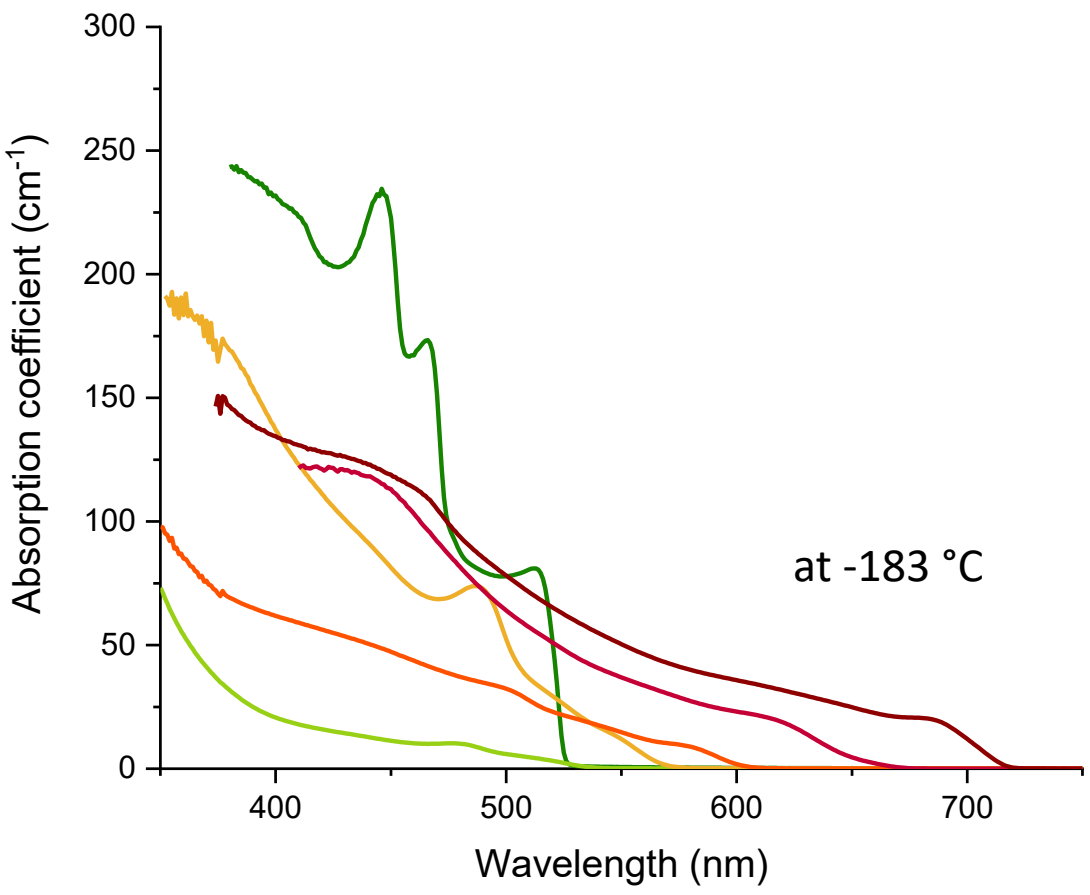
under daylight

Br_1I_0 $Br_{0,6}I_{0,4}$ $Br_{0,5}I_{0,5}$ $Br_{0,4}I_{0,6}$ $Br_{0,25}I_{0,75}$ Br_0I_1

under UV irradiation

Absorption spectra

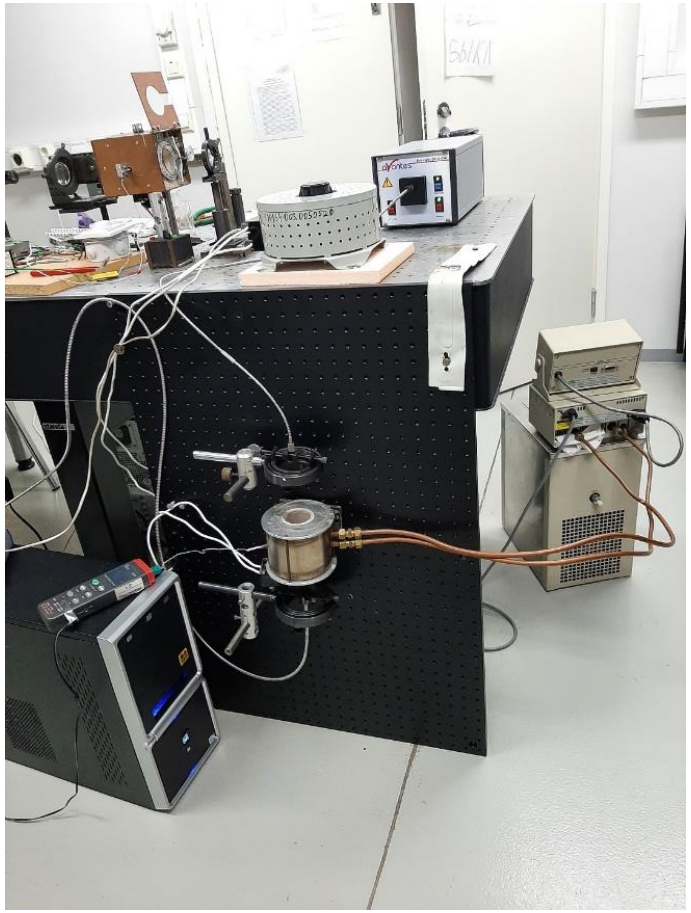


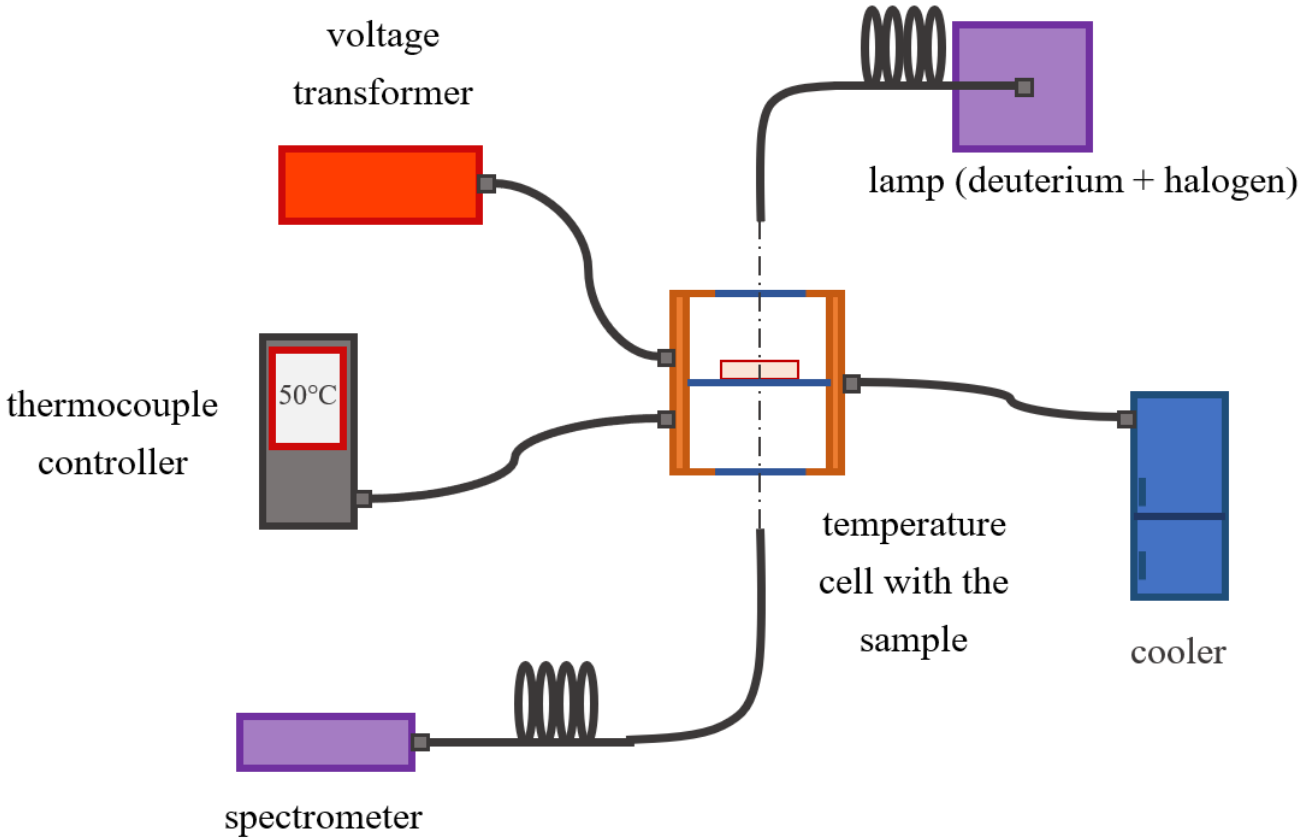


$$\hbar\omega = E_g + 0{,}71\frac{\hbar^2\pi^2}{2\mu a^2}$$

Nanocrystals size 10 – 15 nm

Temperature measurement setup

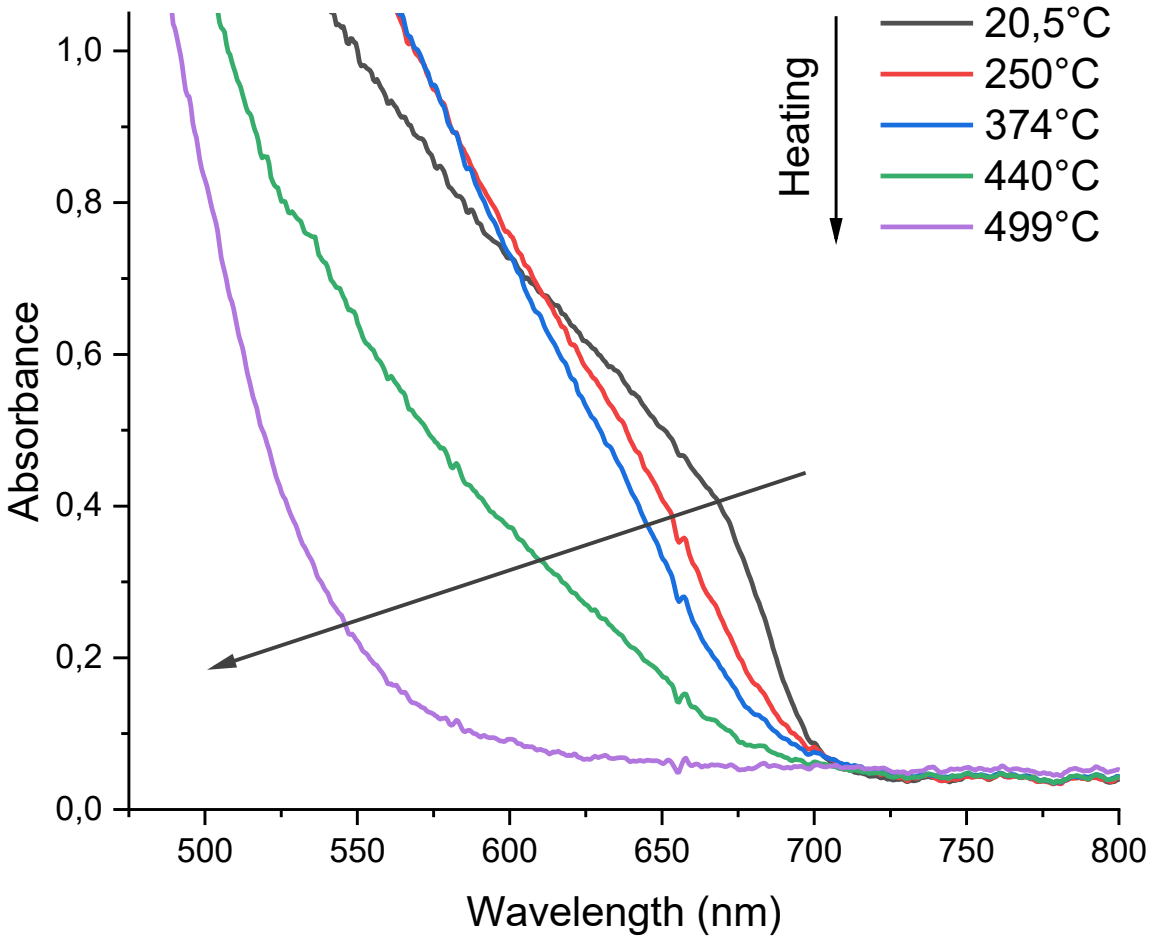


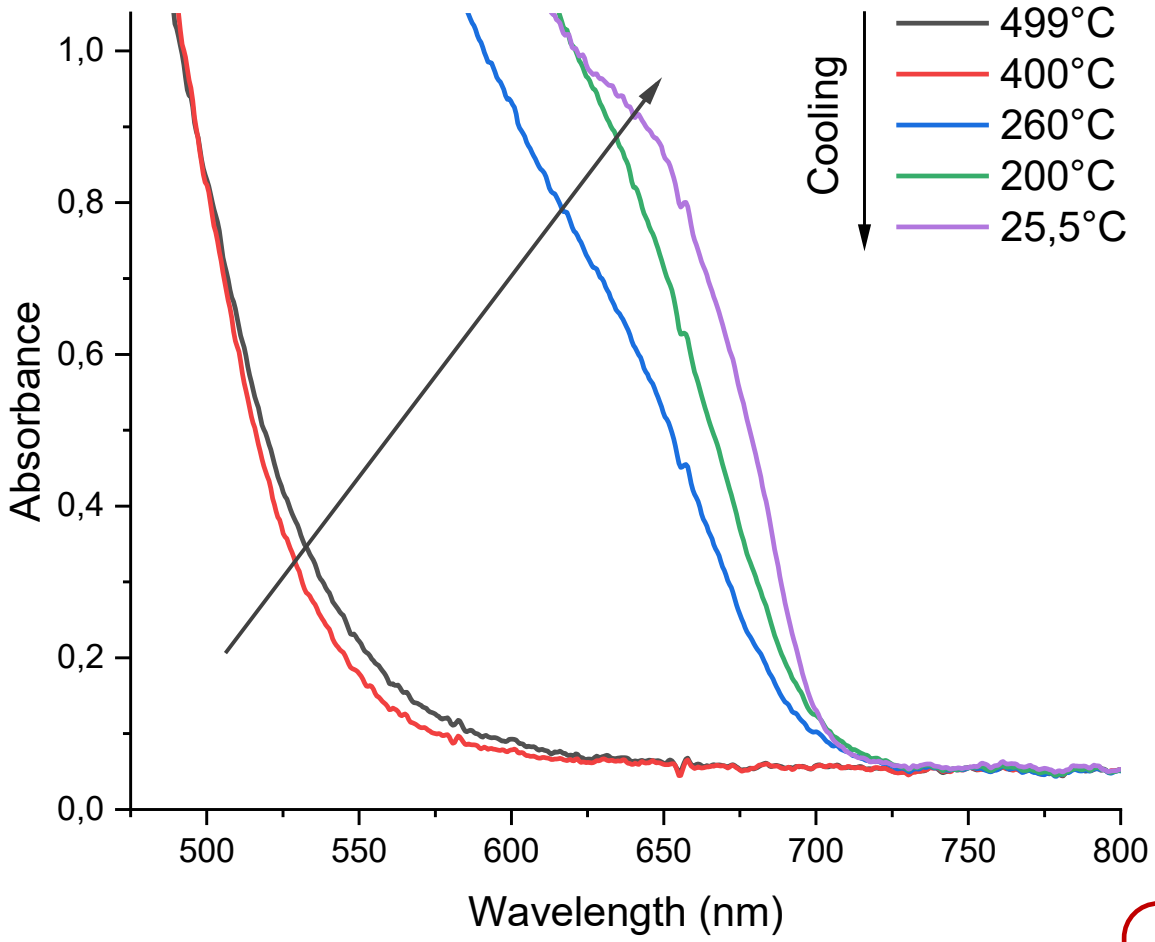


Heating and cooling rates 2±0,5 °C/min

Absorbance spectra evolution during heating-cooling process

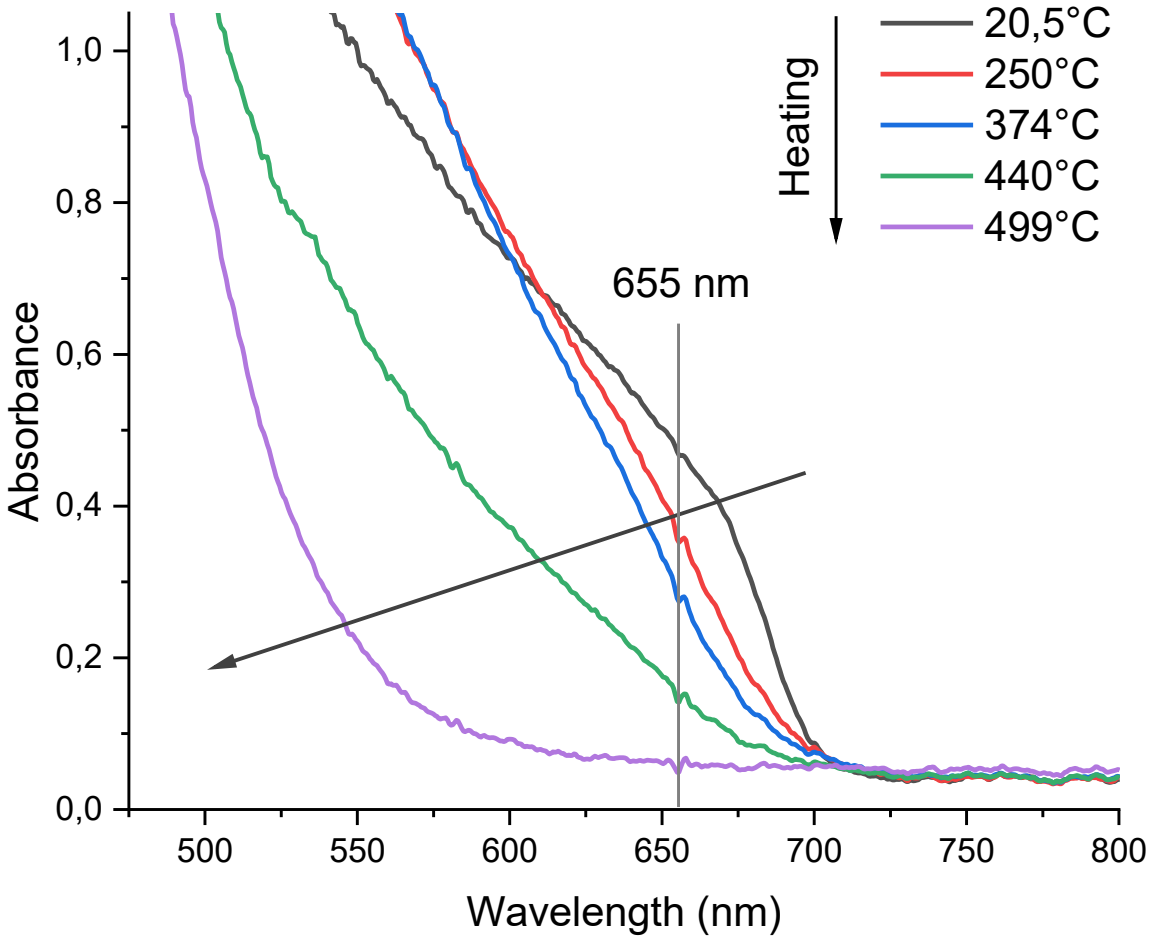
Br_0I_1

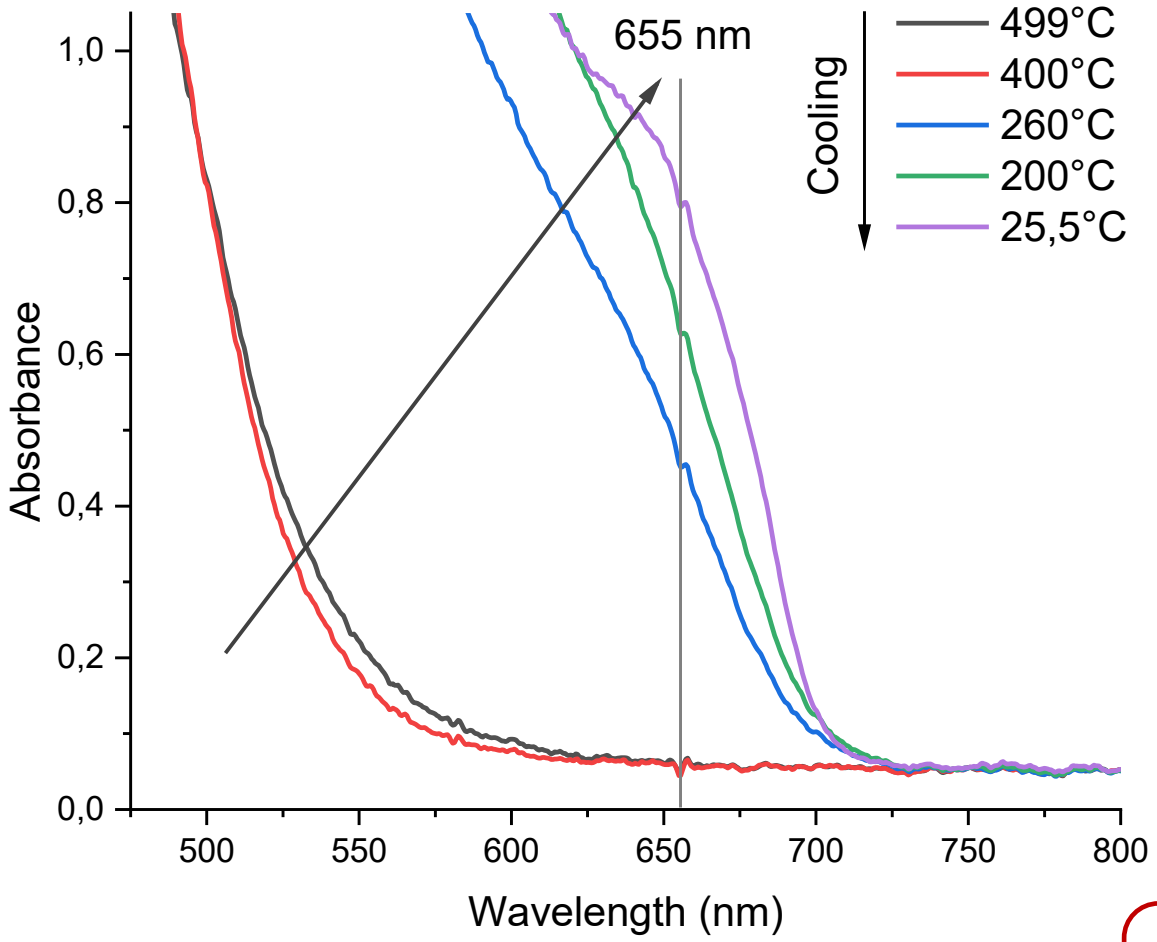




Absorbance spectra evolution during heating-cooling process

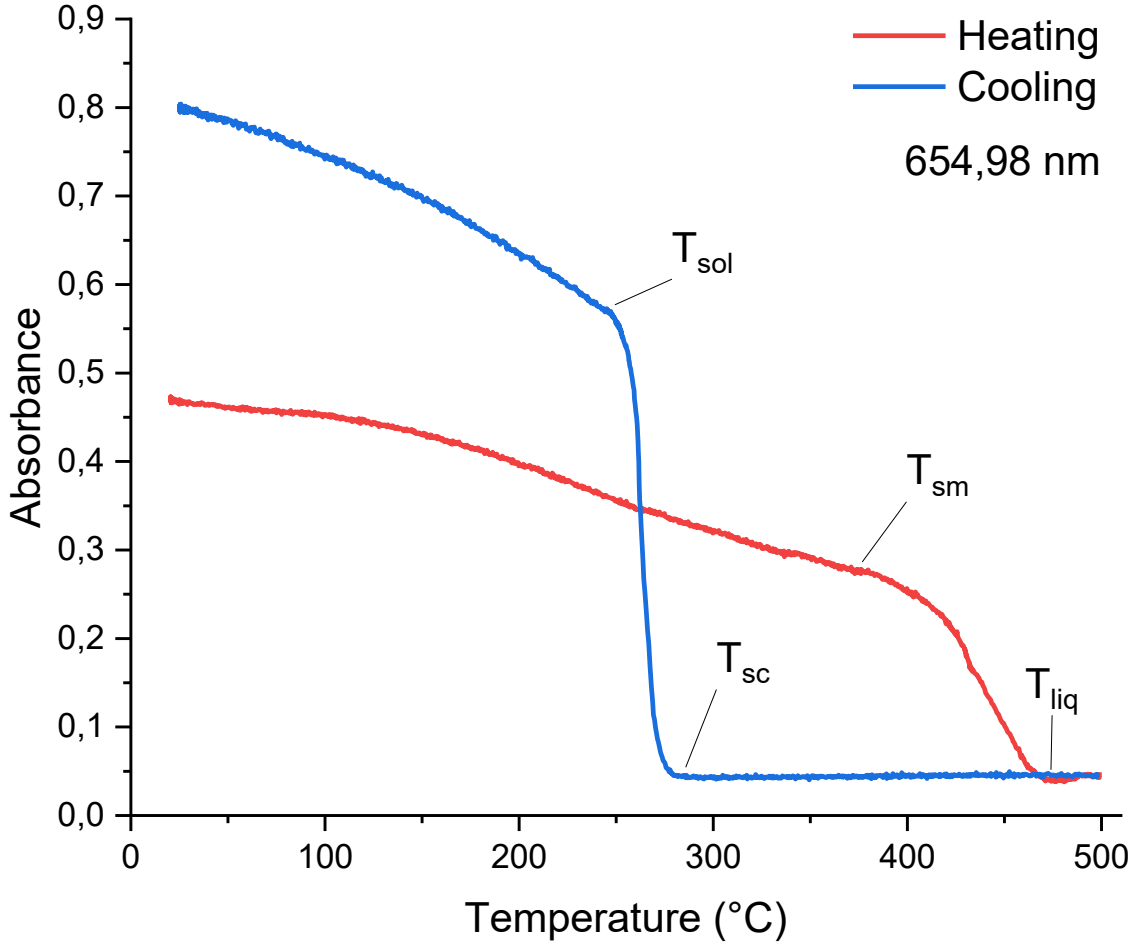
Br_0I_1





Dependence of absorbance on temperature

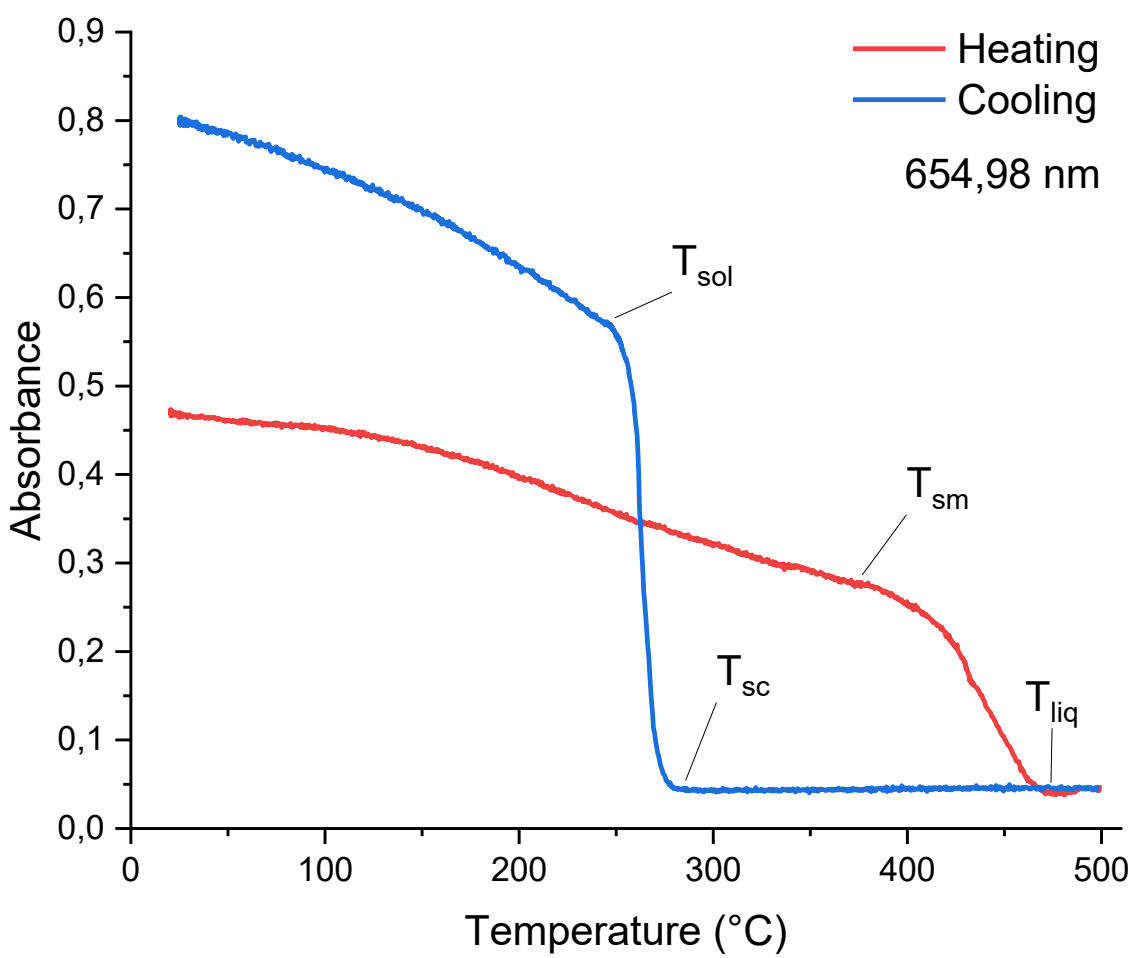
Br_0I_1

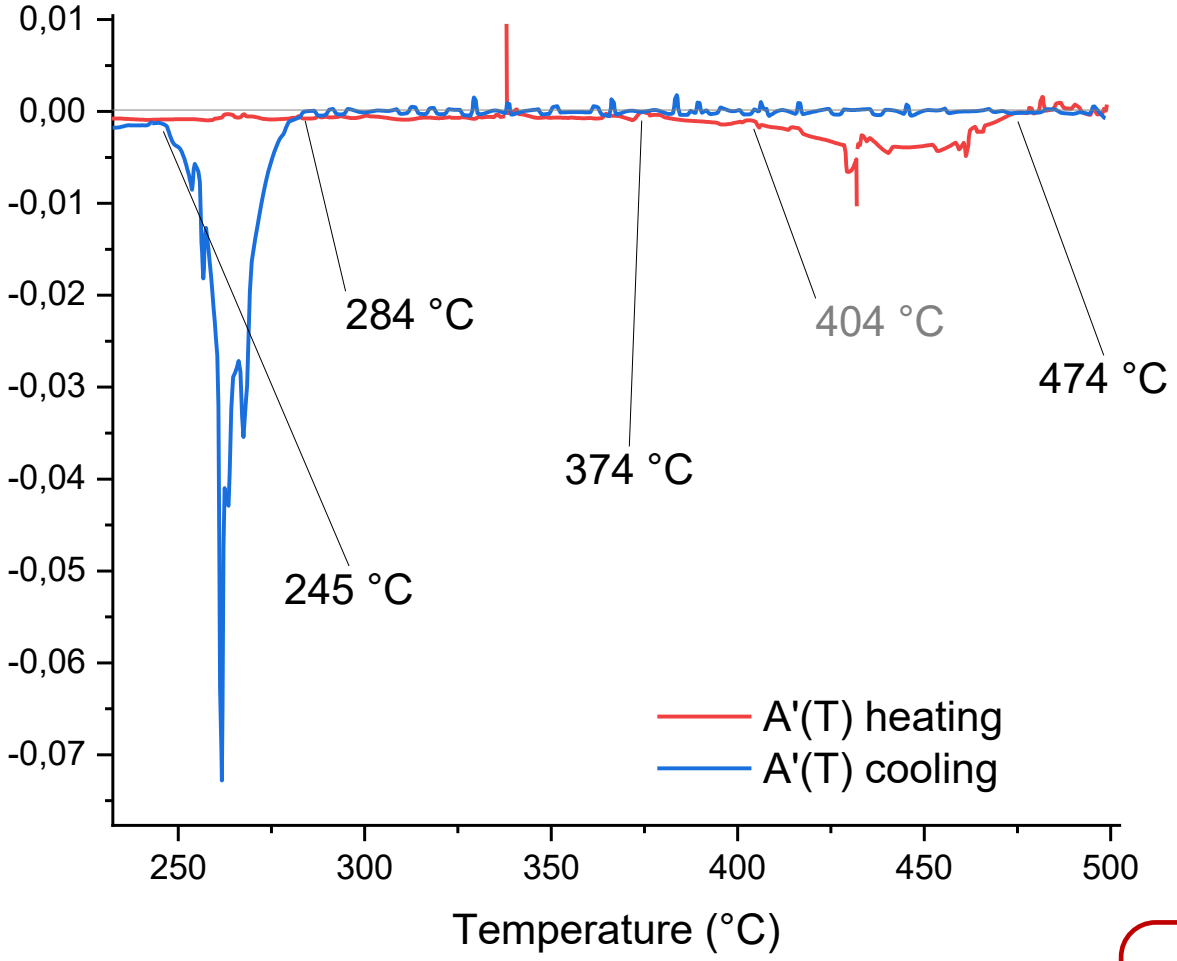


T_{sm} – start of the melting
T_{liq} – liquidus
T_{sc} – start of the crystallization
T_{sol} – solidus

Dependence of absorbance on temperature

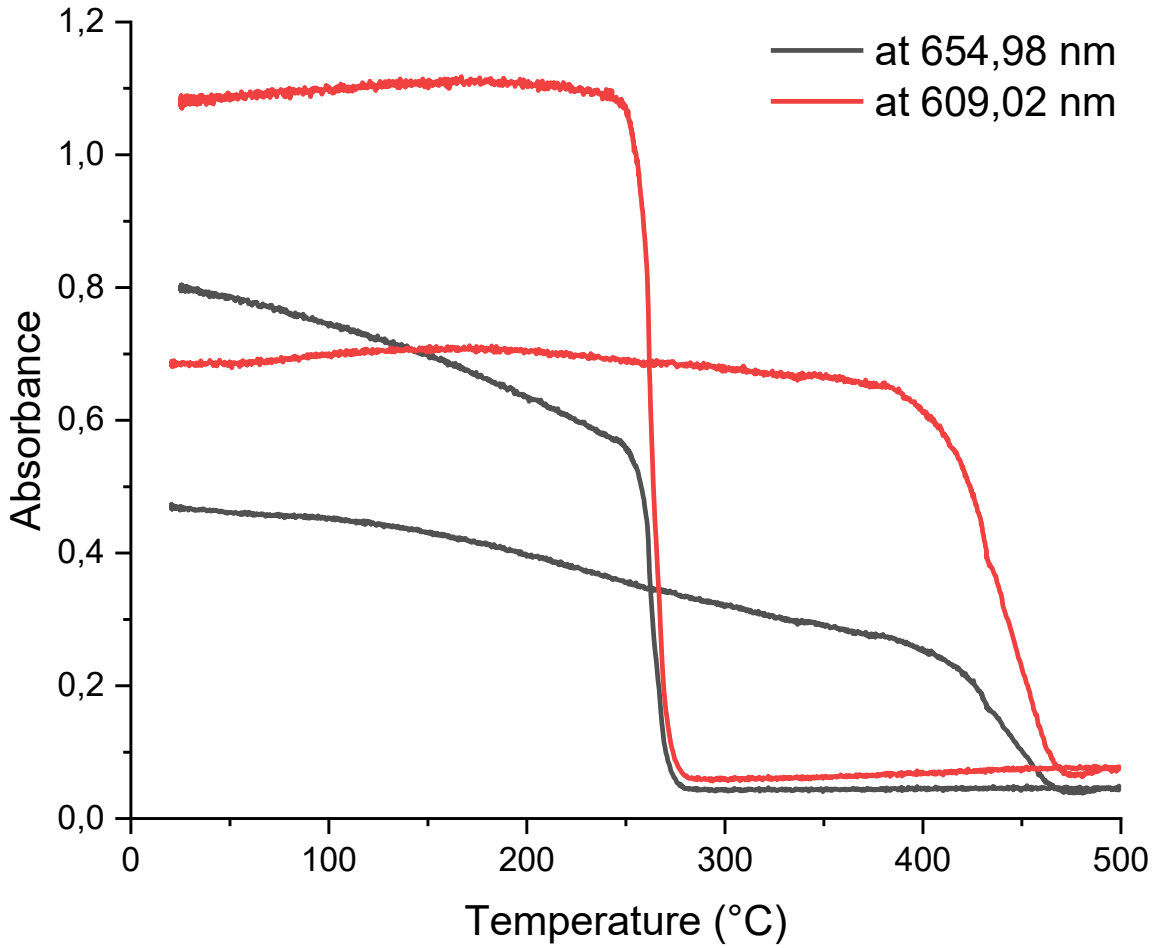
Br_0I_1



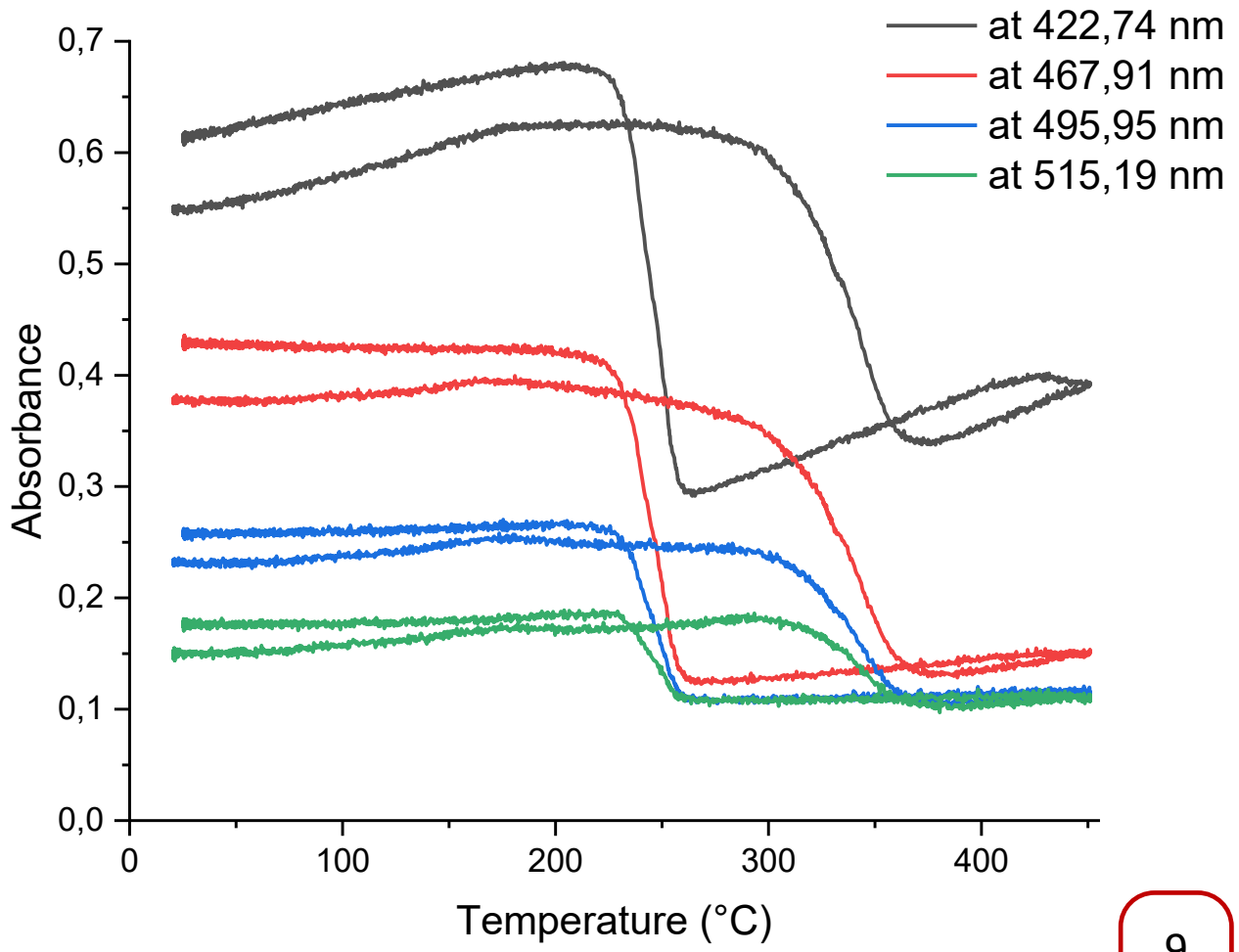


Dependence of absorbance on temperature

Br_0I_1

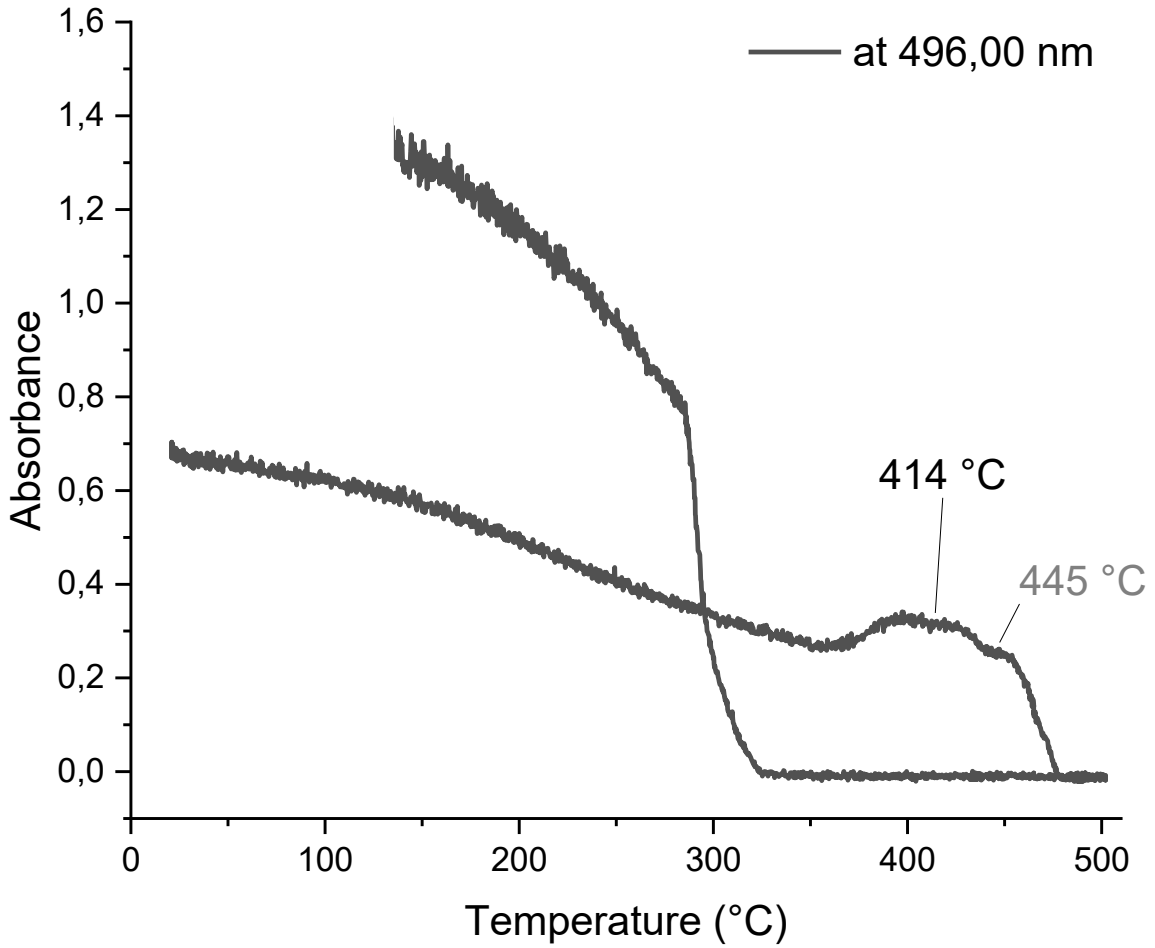


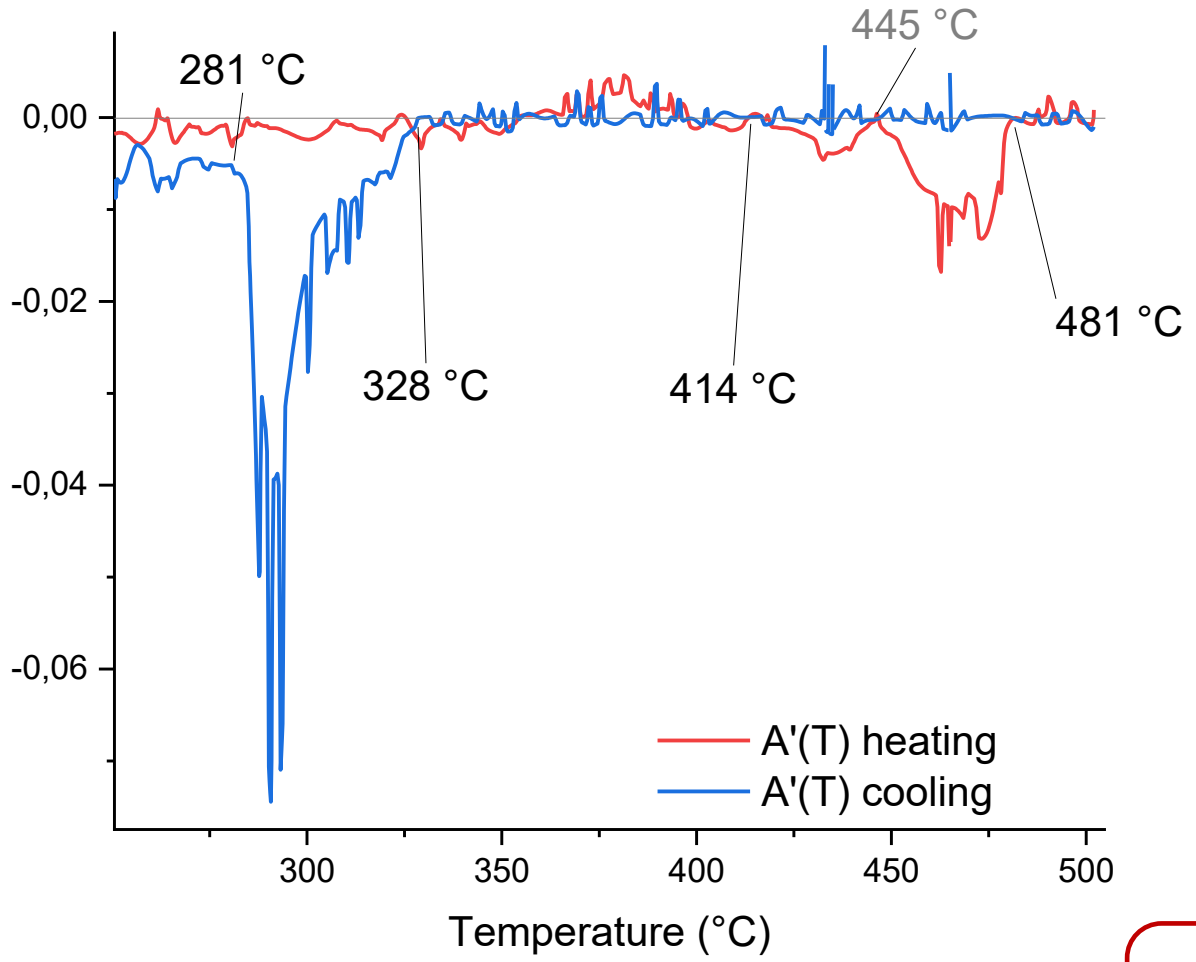
$Br_{0,6}I_{0,4}$



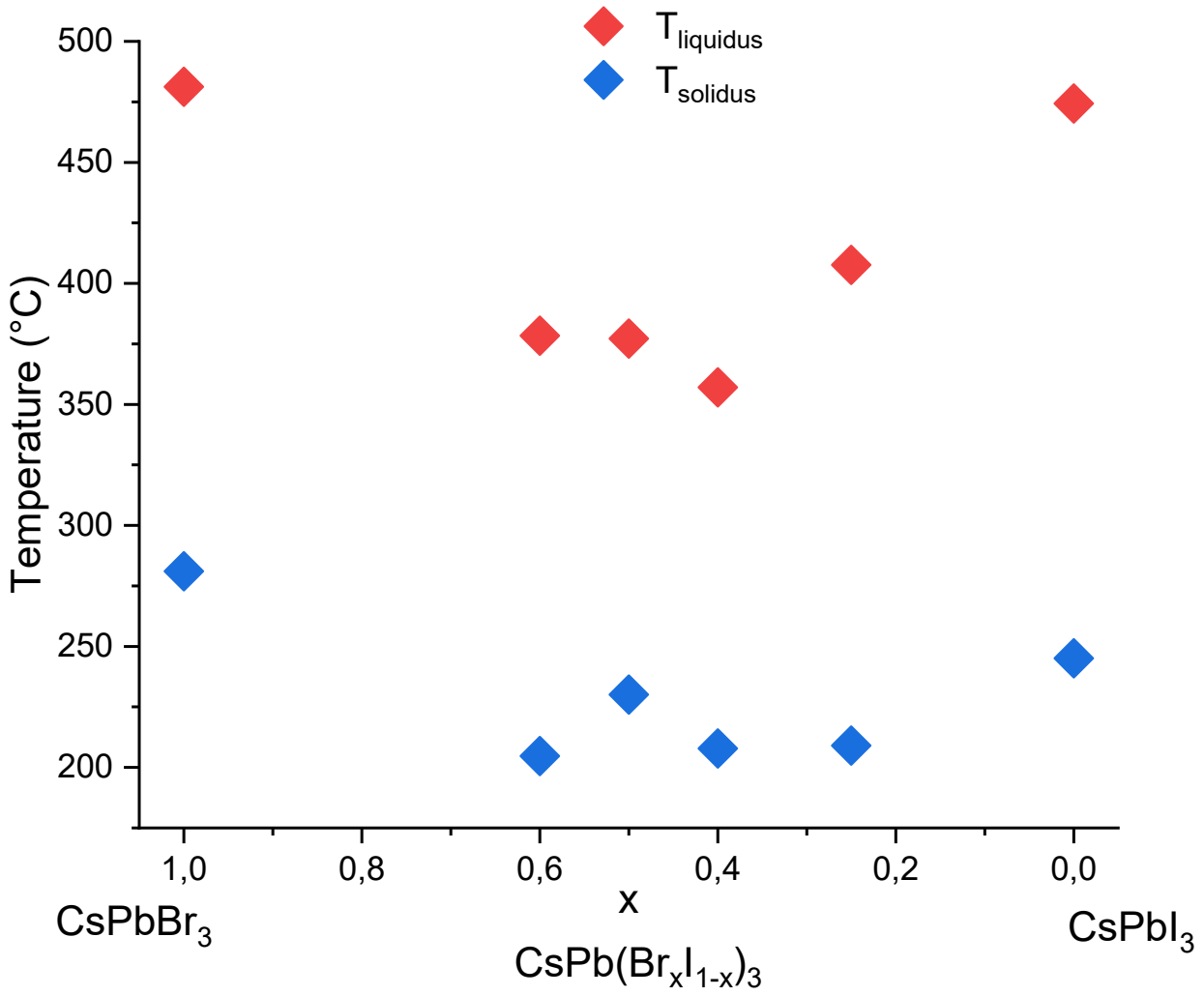
Dependence of absorbance on temperature

Br_1I_0





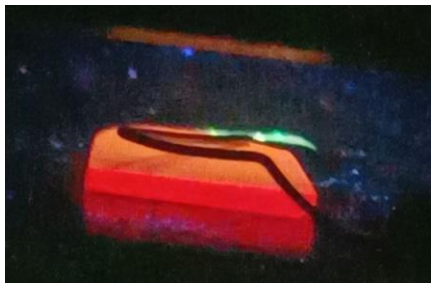
Dependence of solidus and liquidus temperatures on Br/I ratio



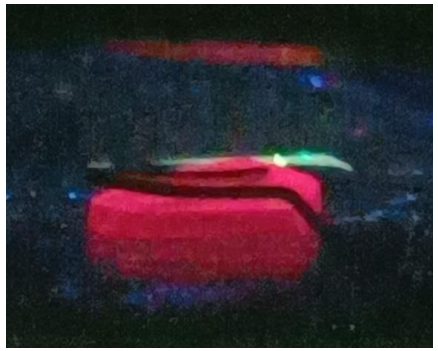
X-ray induced luminescence

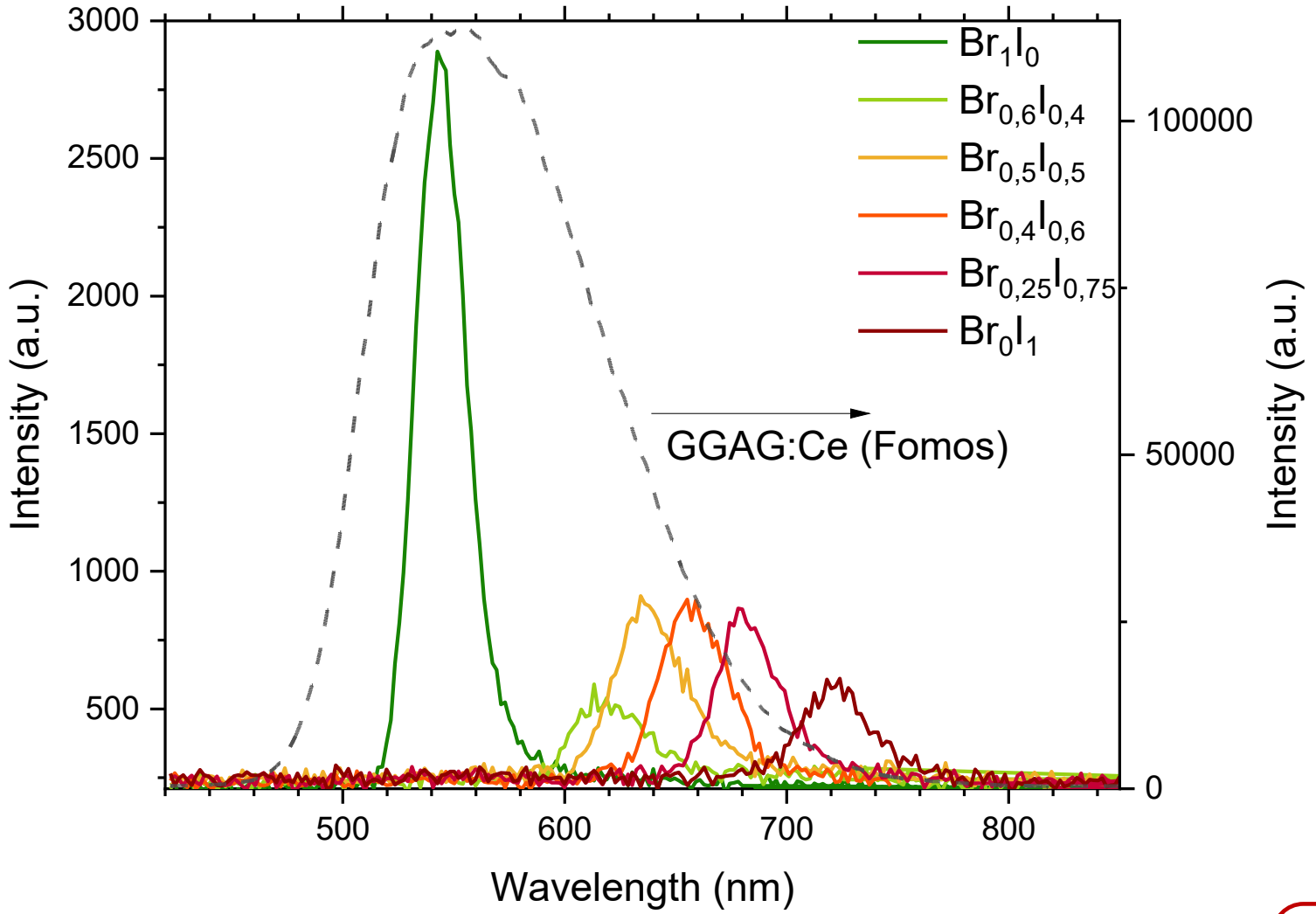
Br_1I_0

$Br_{0,6}I_{0,4}$



$Br_{0,5}I_{0,5}$





Measured by R. Shendrik at A.P. Vinogradov Institute of Geochemistry of SB RAS, Irkutsk

Conclusions

- Borogermanate glass-ceramics with mixed **$CsPb(Br_xI_{1-x})_3$** nanocrystals was **synthesized**.
- Equimolar **replacement of bromine with iodine** in glass-ceramics leads to a **shift o**f absorption **spectra** towards **larger wavelengths**.
- **Hysteresis** was observed in the curves of the dependence of the **absorbance** of glass-ceramics **on temperature**.
- The **shapes** of the curves obtained at different wavelengths are **the same**.
- The dependence of the **liquidus** (350 – 500 °C) and **solidus** (200 – 300 °C) **temperatures** on the nanocrystals composition was obtained.
- The synthesized glass-ceramics displays **X-ray induced luminescence**.

Thank you for your attention!

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