Lasing and spectroscopic properties of Y_2O_3, Lu_2O_3 and Sc_2O_3 ceramics doped with Yb^{3+} ions

V.V. Zelenogorsky[1], E.A. Perevezentsev[1], I.B. Mukhin[1], O.V. Palashov[1], E.A. Khazanov[1], H.Yagi[2], T. Yanagitani[2], H. Yoneda[3], A. Shirakawa[3], K. Ueda[3], and A.A. Kaminskii[4]

[1] *Institute of Applied Physics RAS, Nizhny Novgorod, Russia*

[2] *Takuma Works, Konoshima Chemical Co. Ltd., Kagawa, Japan*

[3] *Institute for Laser Science, University of Electro-Communications, Tokyo, Japan*

[4] *Institute of Crystallography RAS, Moscow, Russia*

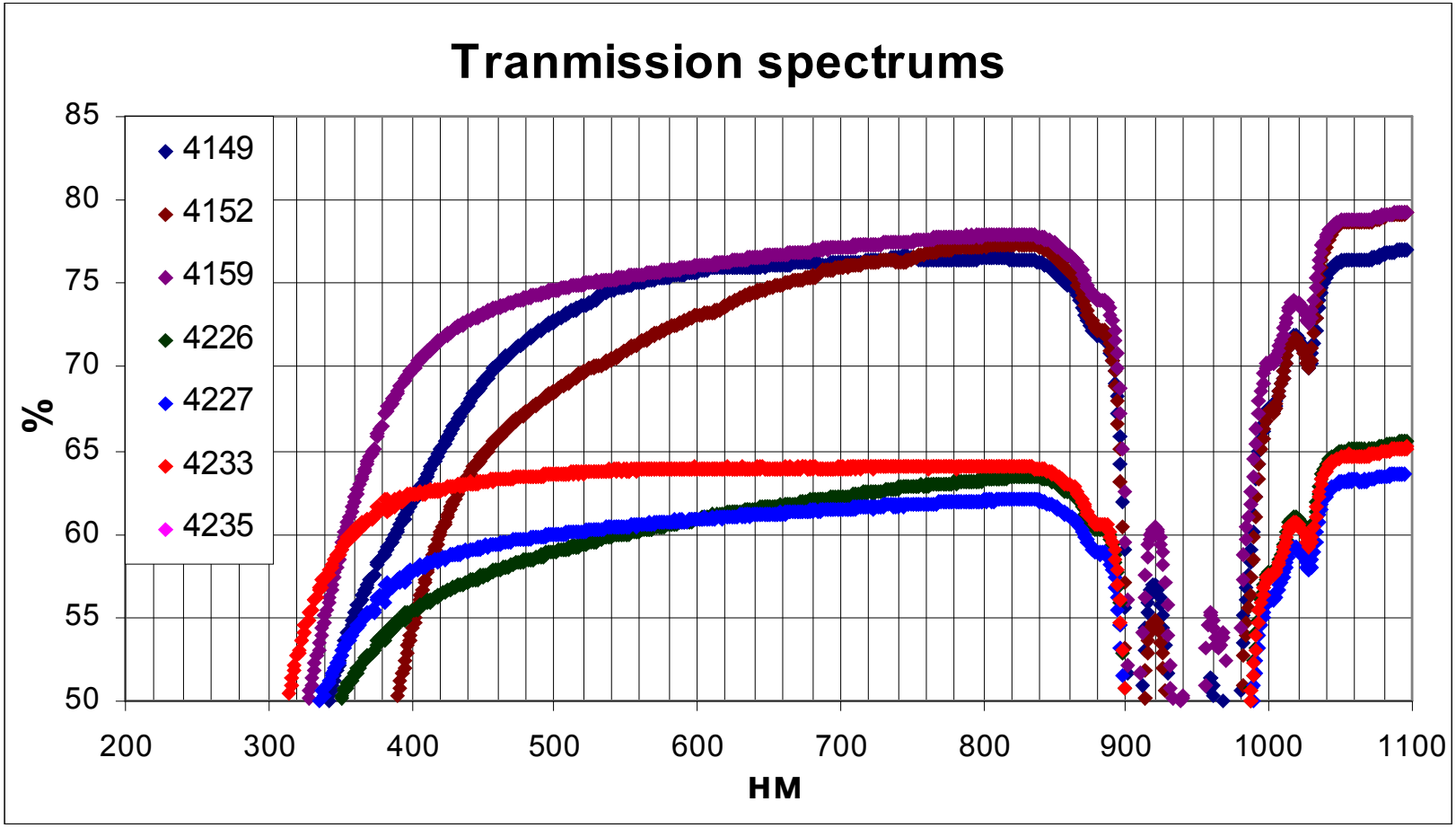
Optical quality estimation

1. Transparency
   a. Transparency spectrums
   b. Absorption and scattering
2. Lasing
   a. Slope efficiency
   b. Lasing and luminescence spectrums
3. Lasing parameter for cryogenic application
   a. Lifetime
   b. Emission cross-section

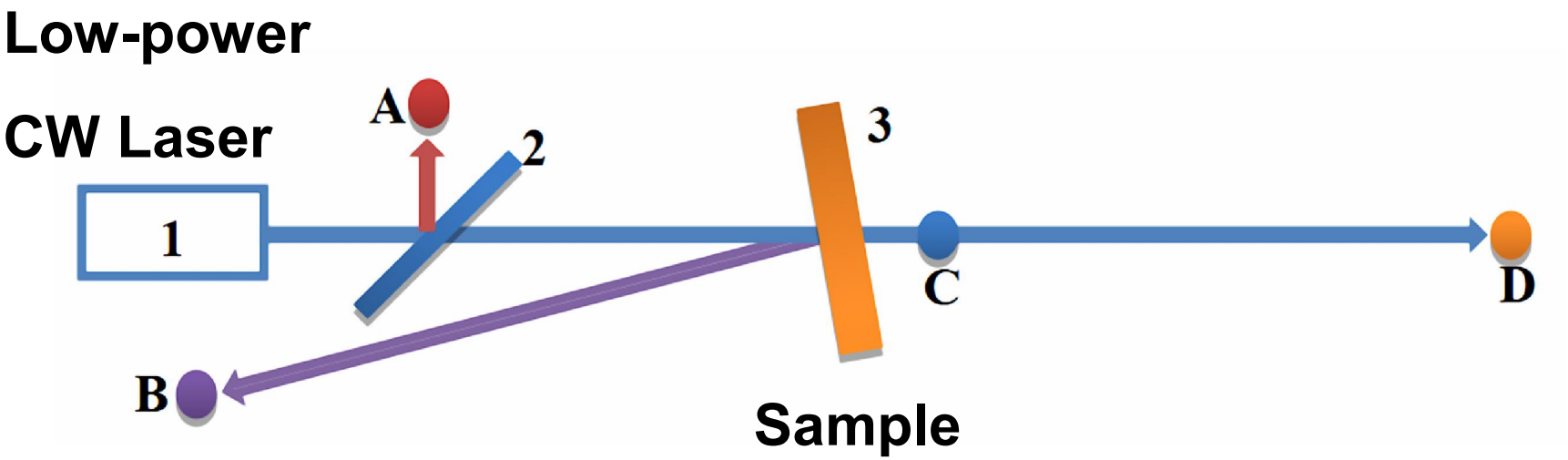
Optical quality estimation

1. Transparency
   a. Transparency spectrums
   b. Absorption and scattering
2. Lasing
   a. Slope efficiency
   b. Lasing and luminescence spectrums
3. Lasing parameter for cryogenic application
   a. Lifetime
   b. Emission cross-section

Optical transparency



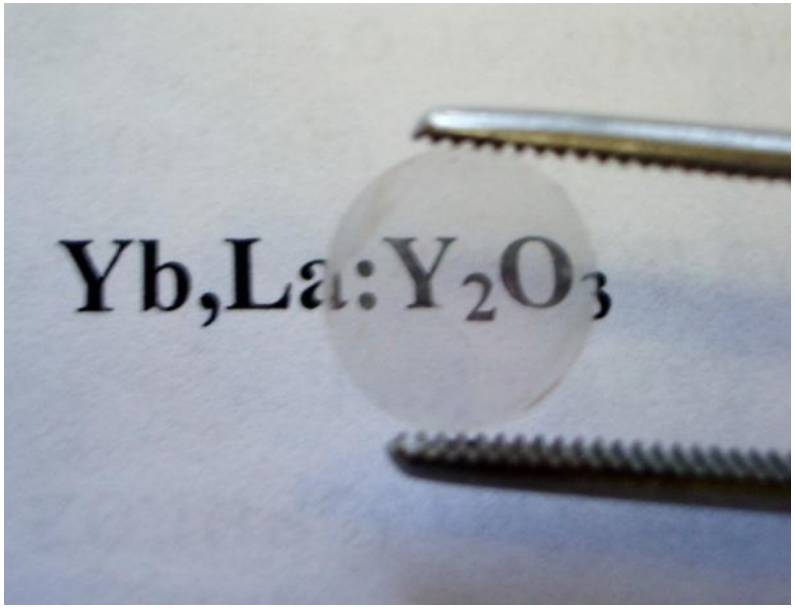
Measuring absorption and scattering



Lanthanum

Nizhny Novgorod, Russia
S.S. Balabanov[1], E.M. Gavrishchuk[1], D.A. Permin[1]
S.V. Egorov[2], A.G. Eremeev[2], Yu.V. Bykov[2],
[2] Institute of Chemistry of High-Purity Substances RAS
[1] Institute of Applied Physics, Russian Academy of Sciences

To produce a highly transparent material during sintering several additives are often used, such as ZrO_2, La_2O_3, Gd_2O_3 and others



Lanthanum

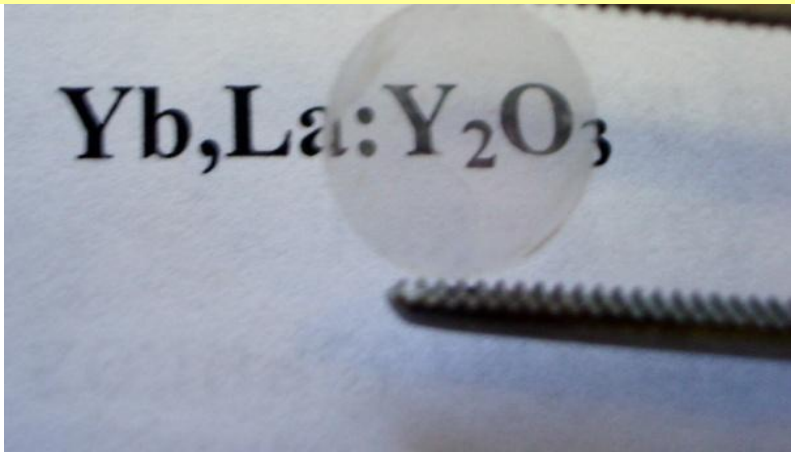
DMITRY PERMIN (Thursday 15:10)

Self-propagating high temperature synthesis of rare-earth oxide nanopowders for transparent ceramics

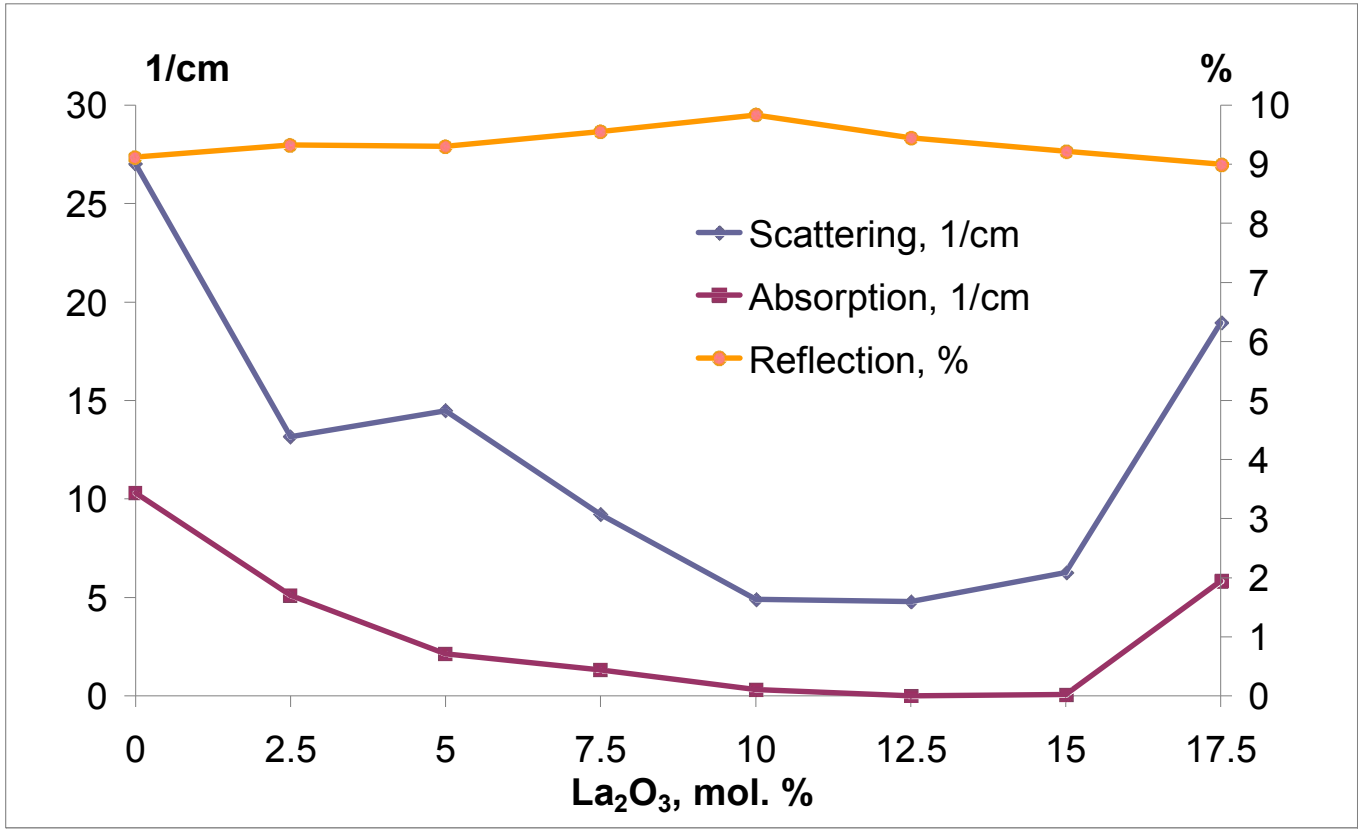
Institute of Applied Physics, Russian Academy of Sciences

SERGEY EGOROV (Thursday 09:30)

Fabrication of transparent ceramics by millimeter-wave sintering



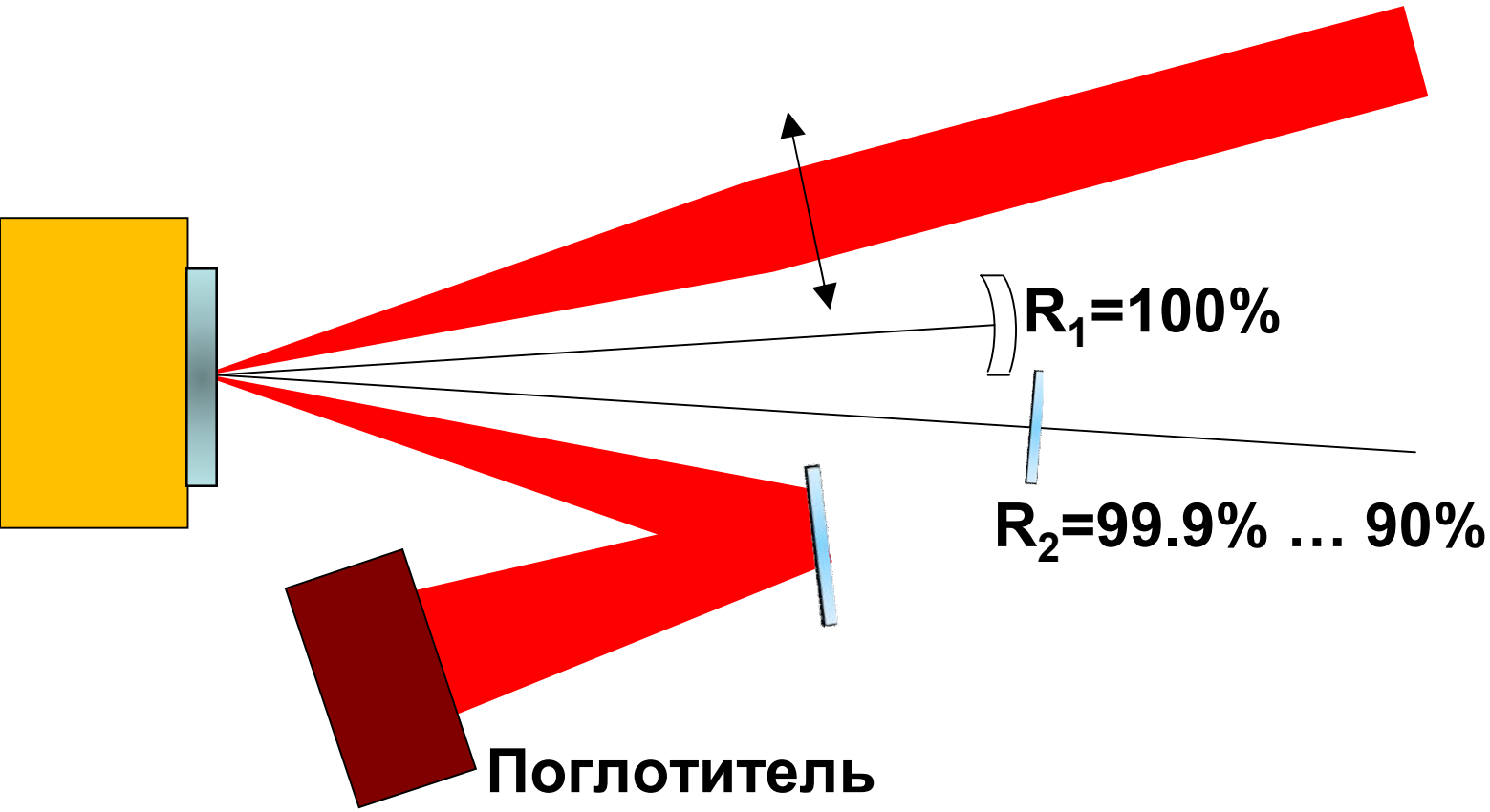
Selecting the best Lanthanum concentration



Optical quality estimation

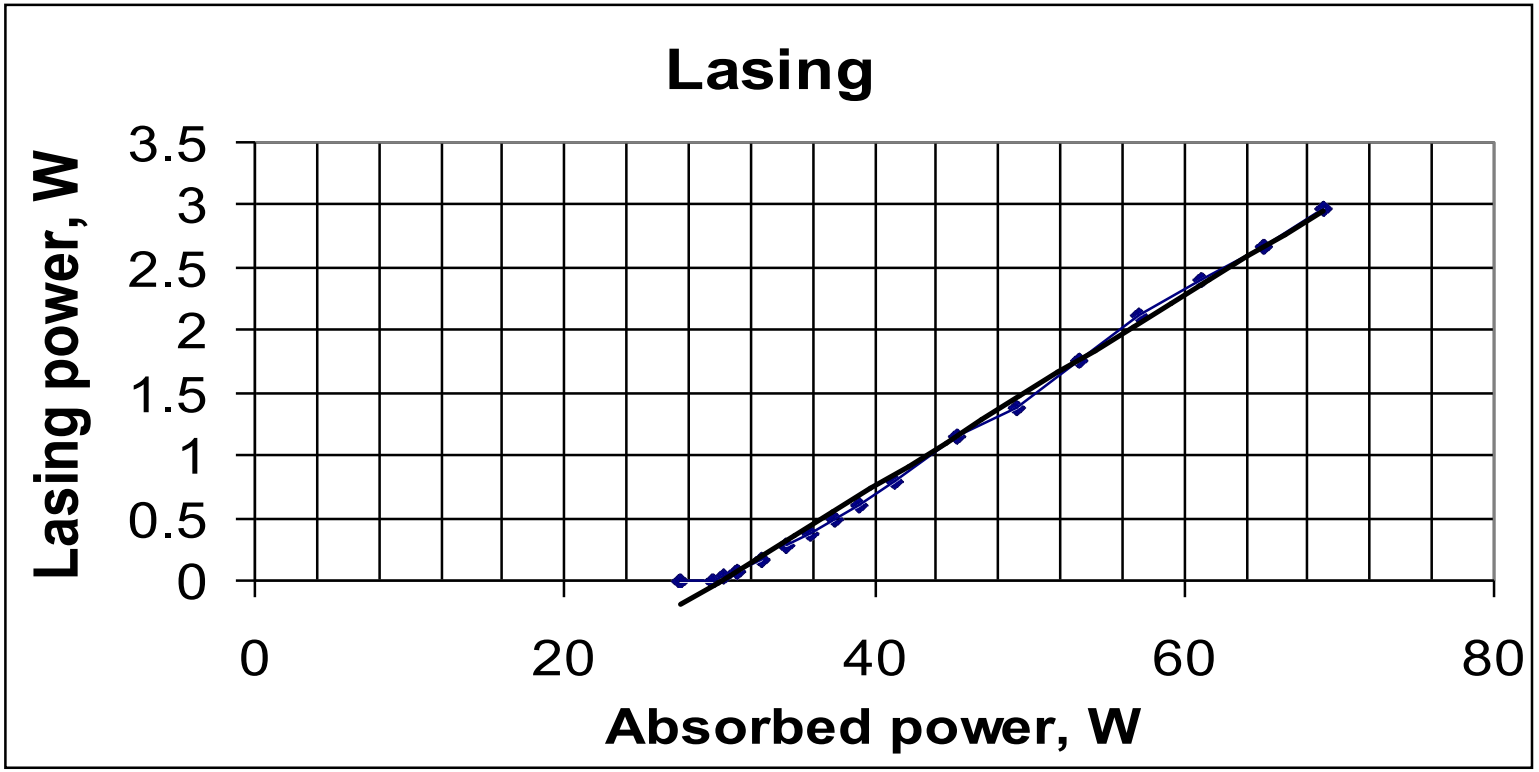
1. Transparency
   a. Transparency spectrums
   b. Absorption and scattering
2. Lasing
   a. Slope efficiency
   b. Lasing and luminescence spectrums
3. Lasing parameter for cryogenic application
   a. Lifetime
   b. Emission cross-section

Lasing experiments

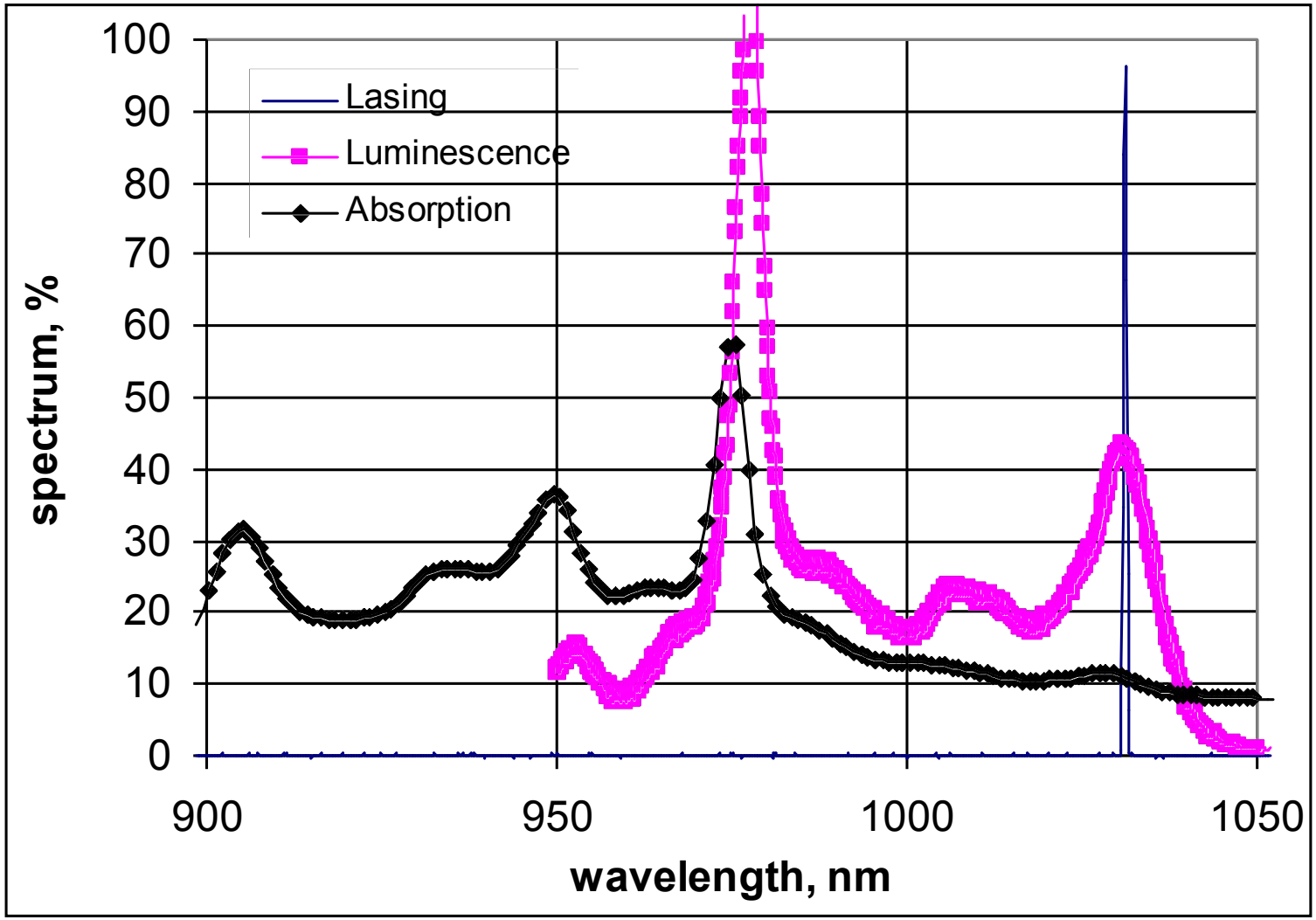


Lasing results

SHS-MS Yb,La:Y_2O_3 ceramics
Slope efficiency was **8%**
(for 4.5% transmission of output mirror)



Absorption and Luminescence spectrums



Optical quality estimation

1. Transparency
   a. Transparency spectrums
   b. Absorption and scattering
2. Lasing
   a. Slope efficiency
   b. Lasing and luminescence spectrums
3. Lasing parameter for cryogenic application
   a. Lifetime
   b. Emission cross-section

Cryogenic applications

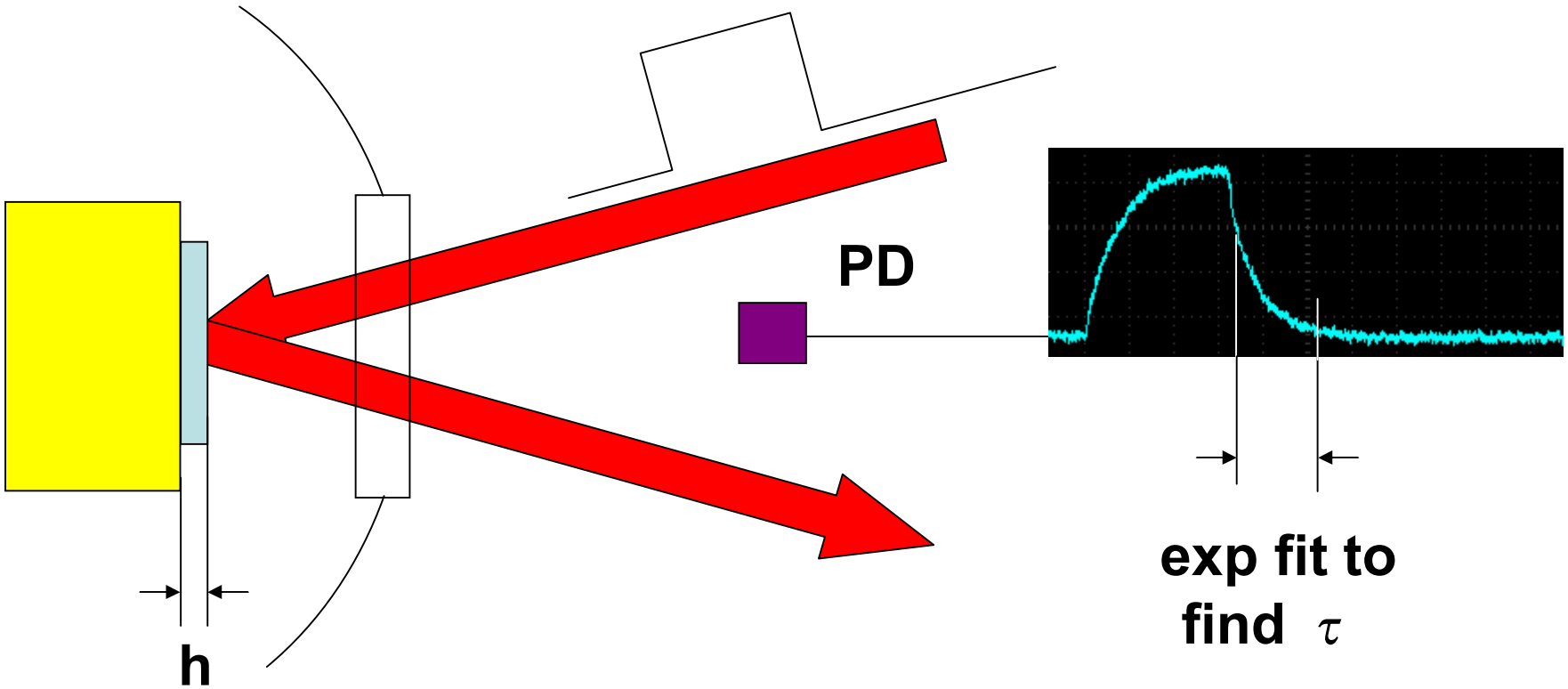
$$\frac{dn}{dT} \downarrow$$ **~10 times**

$$\frac{dl}{dT} \downarrow$$ **~ 5 times**

æ $\uparrow$ **several times**

$$\alpha_{las} \downarrow$$

Measurement of Lifetime



The set of investigated samples

Yb-doped ceramics:

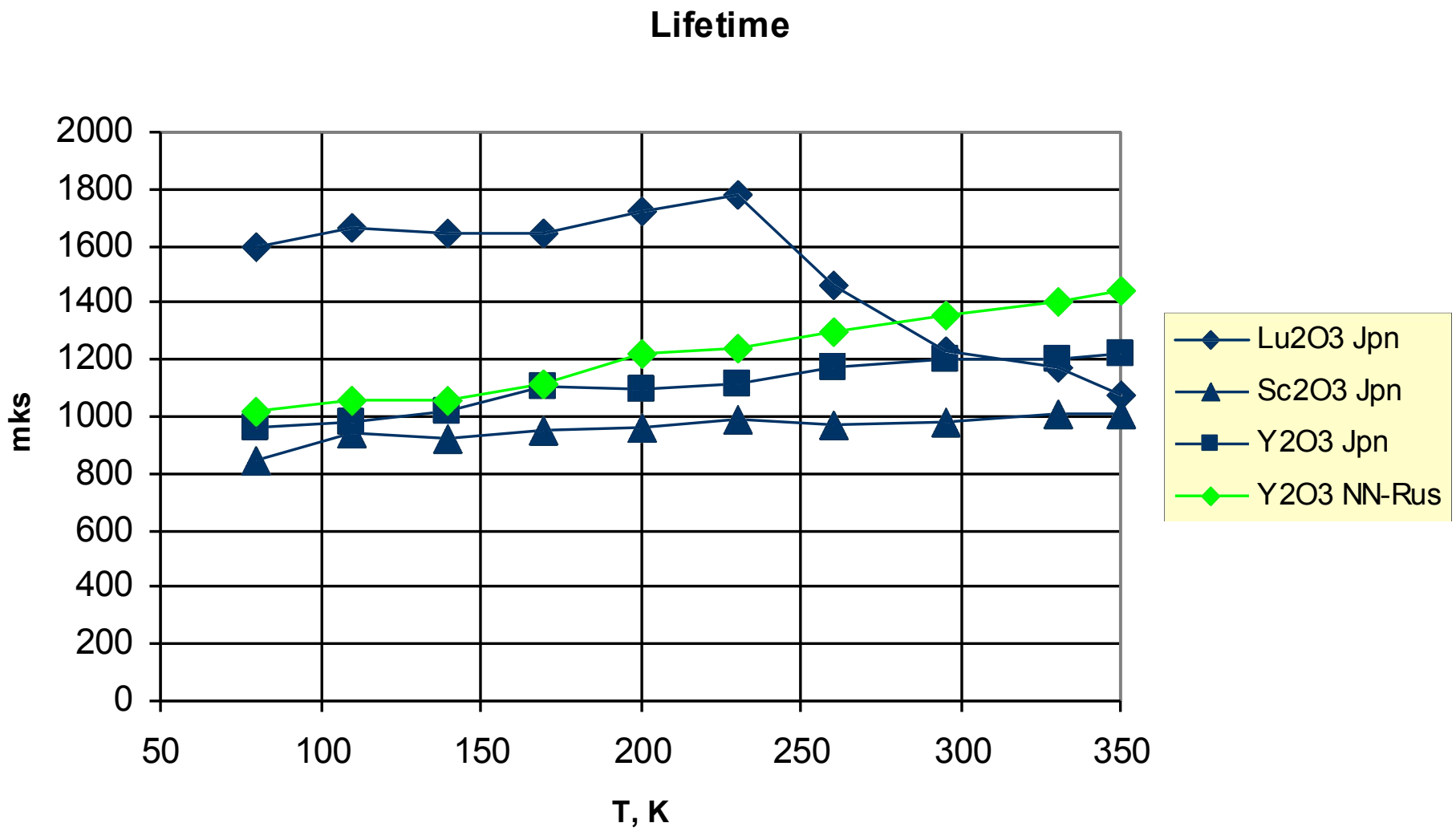
Y_2O_3 **- Japan** (provided by Prof. Kaminsky)
2% Yb

Sc_2O_3 **- Japan** (provided by Prof. Kaminsky)
2% Yb

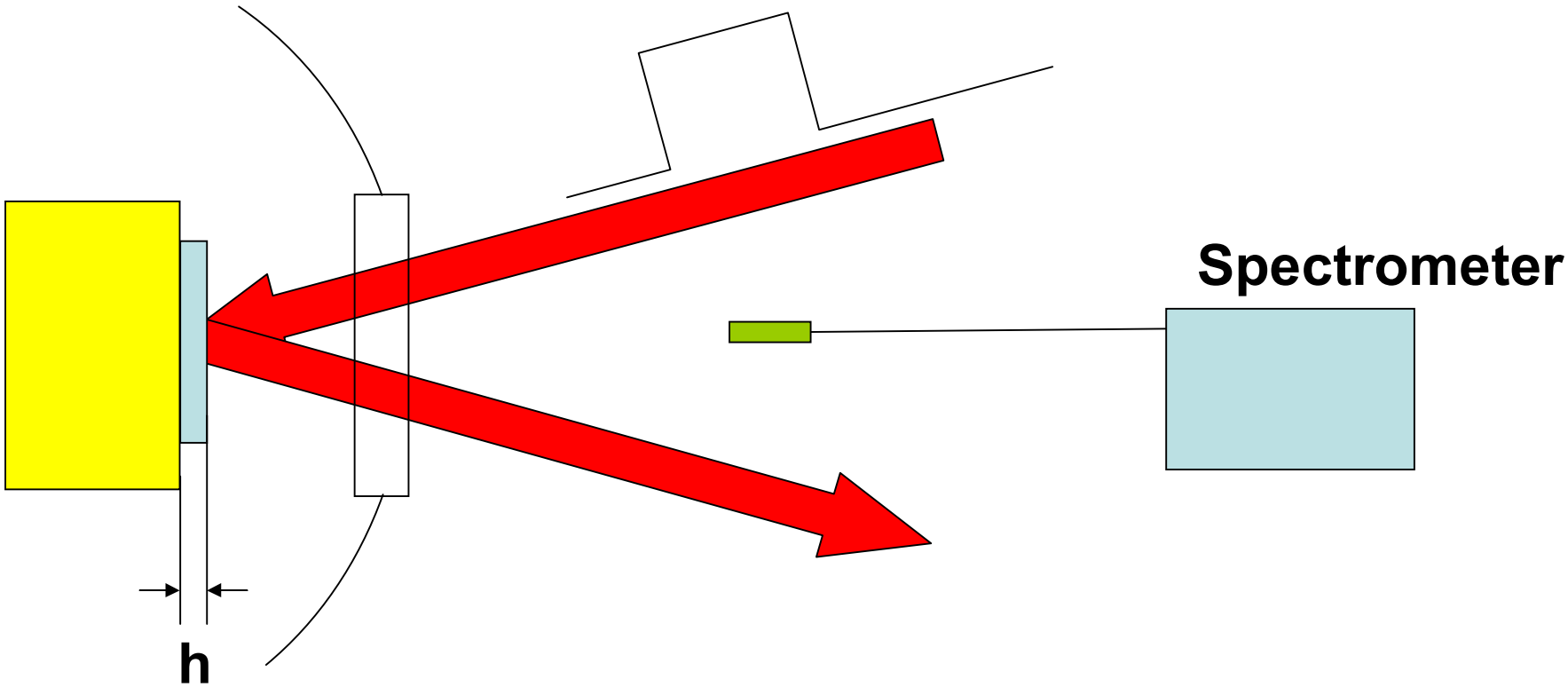
Lu_2O_3 **- Japan** (provided by Prof. Kaminsky)
2% Yb

Y_2O_3 **– Nizhny Novgorod, Russia**
5% Yb

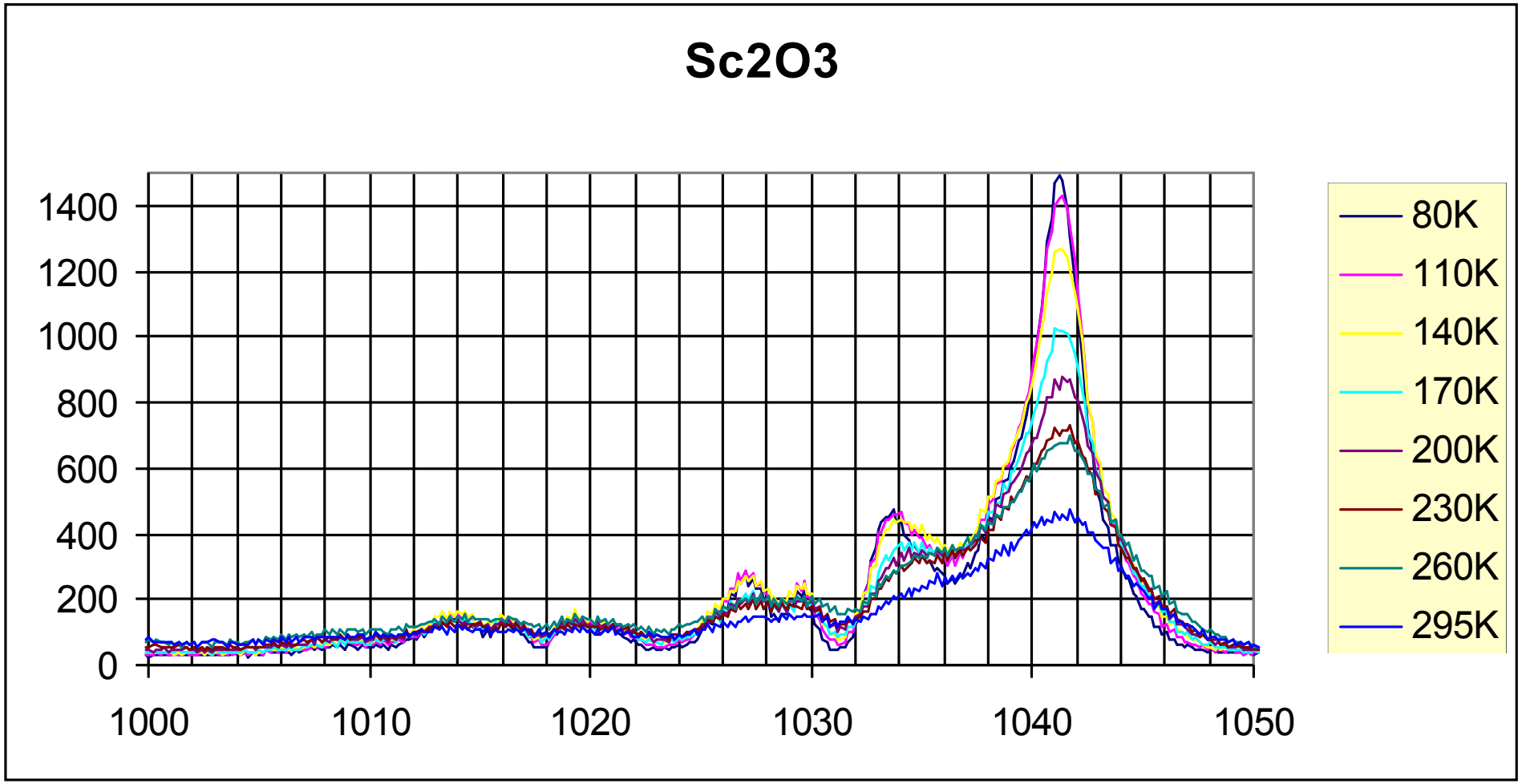
Lifetime measurements



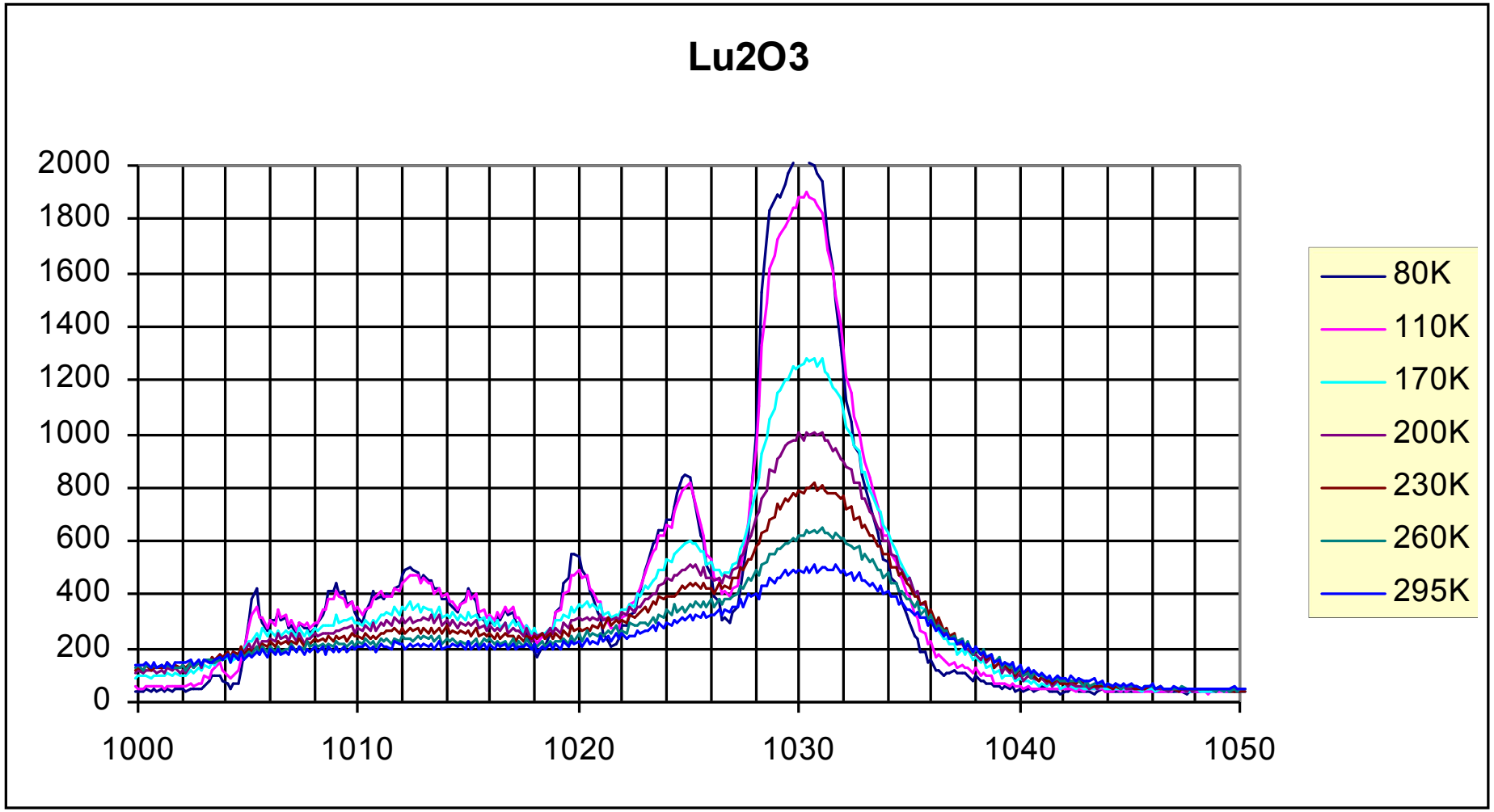
Measurement of Luminescence



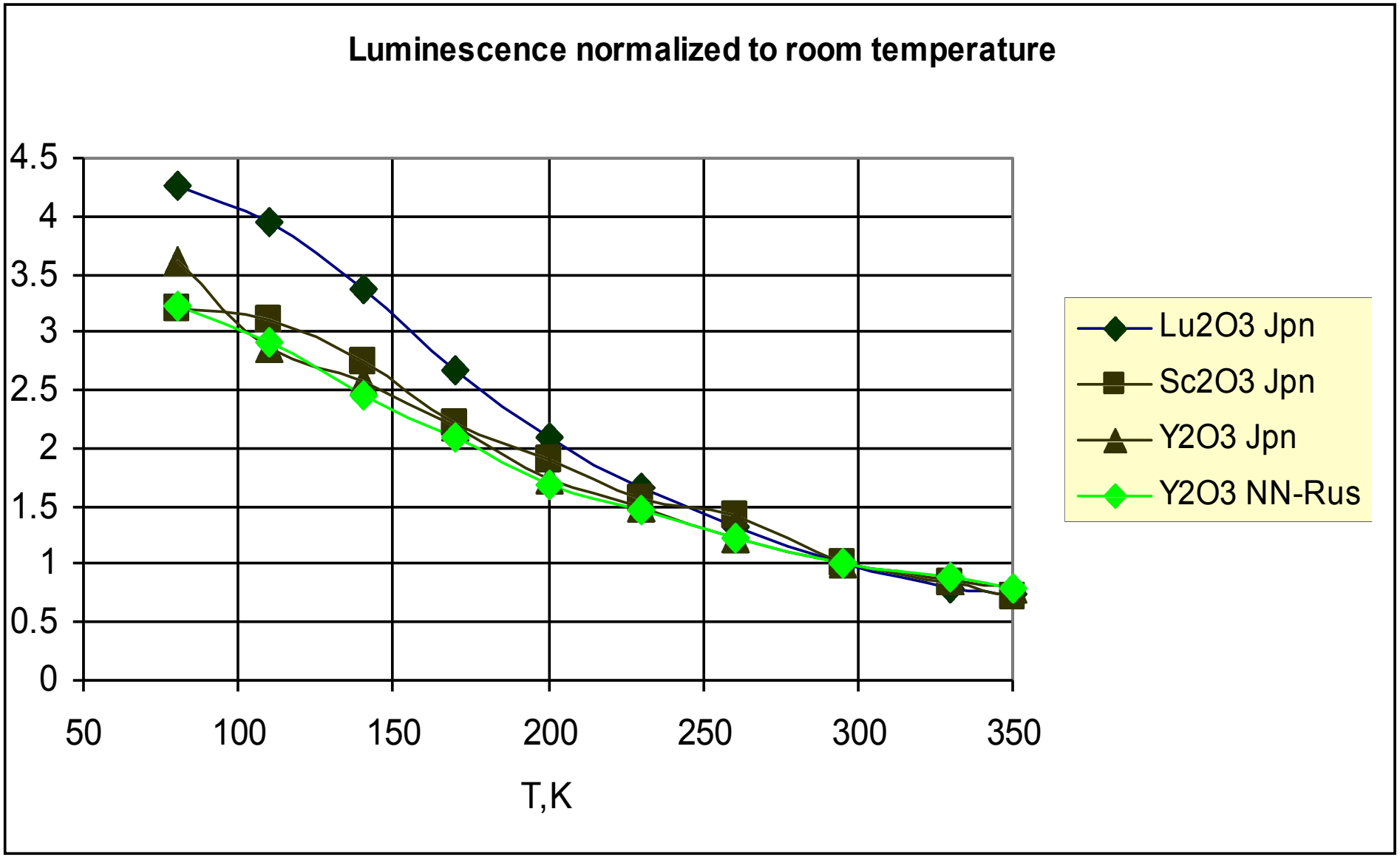
Luminescence spectrum measurements



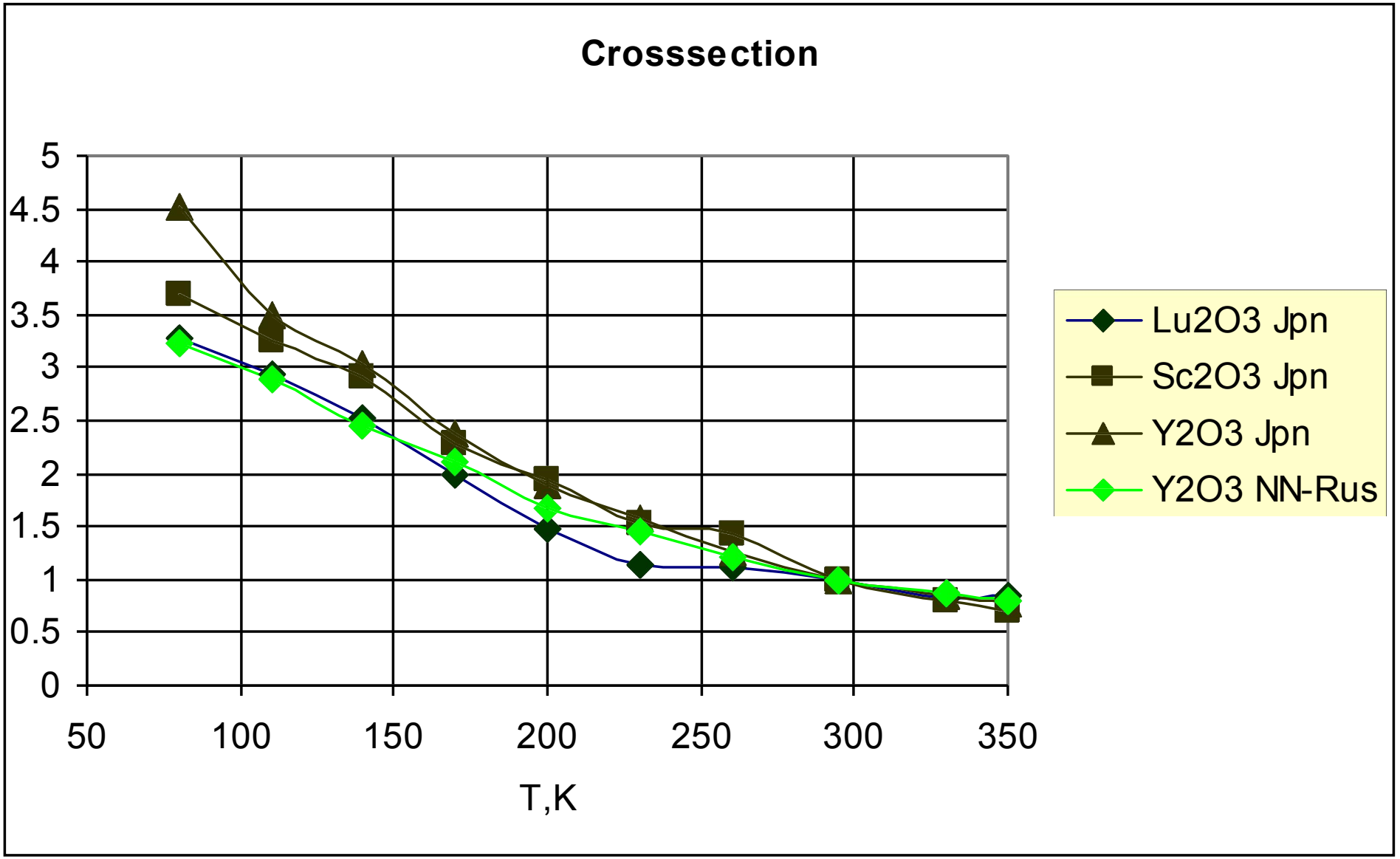
Luminescence spectrum measurements



Luminescence measurements



Emission cross-section



Results

- The set of benchmarking experiments are implemented in our institute to estimate optical quality of ceramics samples
- Performed tests allowed to find optimal concentration of La additive to achieve best optical quality
- SHS-MS ceramics allowed to achieve about 8% of lasing slope efficiency
- Cryogenic tests were done for wide range of samples and allowed to measure 3.5 increase in cross section for oxide ceramics while cooling to cryogenic temperatures
- There was measured decrease of lifetime from 1.1 ms down to 0.9 ms
- About 4nm luminescence spectrums widths at 80K was measured for Lu2O3 ceramics which makes this ceramics more promising for amplification of sub-picosecond pulses.