LUMINESCENCE OF NANOCERAMICS BASED ON YTTRIUM-ALUMINIUM GARNET DOPED WITH NEODIMIUM

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Motivation

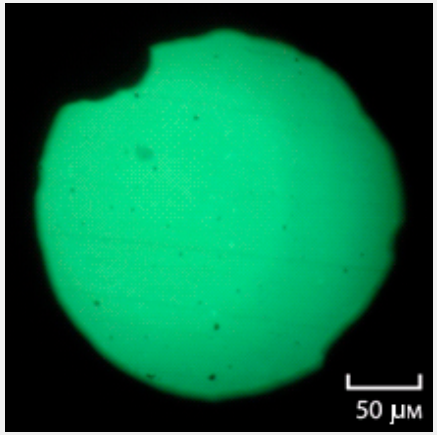
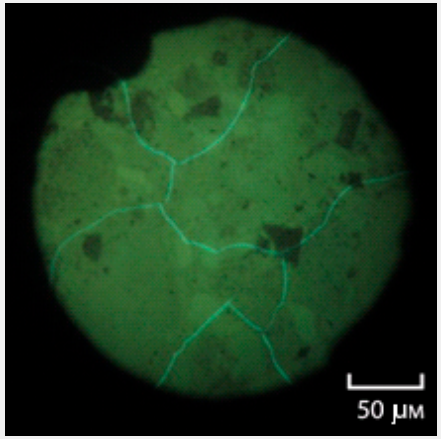
- In the last decade, there is a great interest in obtaining transparent ceramics of $Y_3Al_5O_{12}$ (YAG) doped with RE ions

- Such ceramics, prepared in a low cost way compared to processing of the monocrystals, have comparable optical and thermomechanical properties and can substitute them in many applications

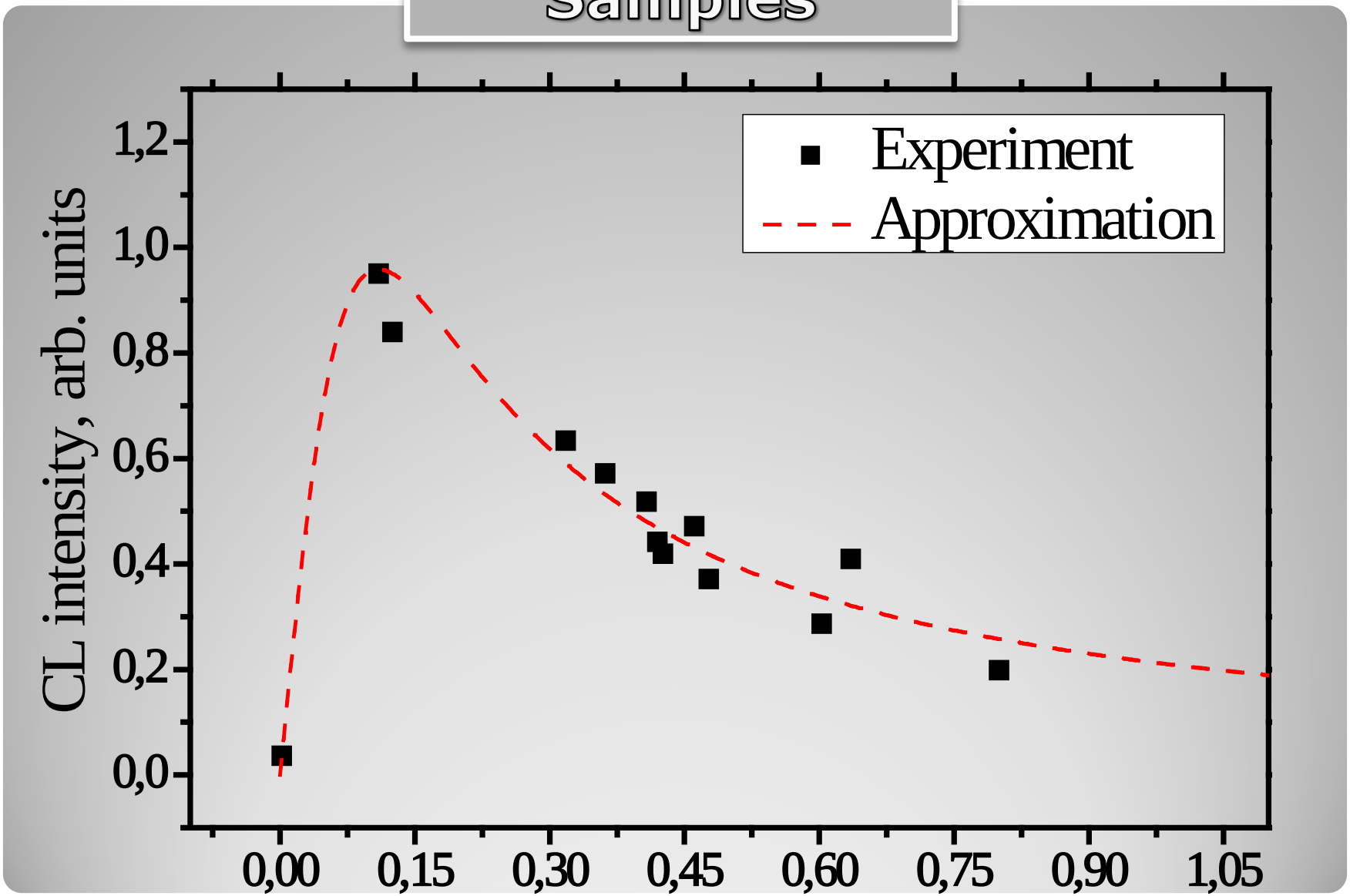
Objectives of work

- CL spectra of YAG:Nd crystal and nanoceramics with a resolution of 0.1 nm in the infrared, visible and ultraviolet ranges;
- Times of decay of each CL band after excitation for both materials;
- Study of CL intensity behavior (degradation in monocrystal or rise in case of YAG:Nd nanoceramics) under continuous irradiation by electron beam;

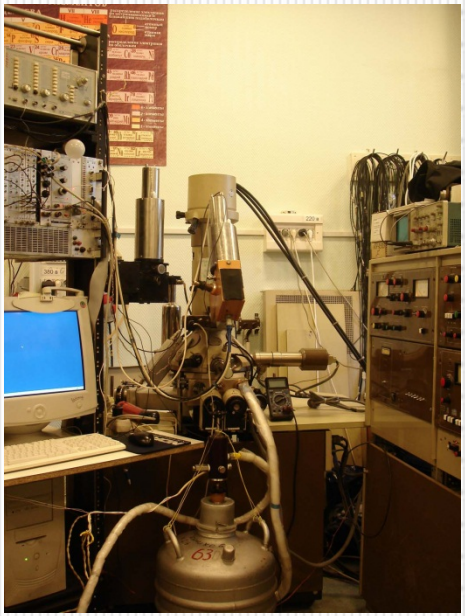
Samples

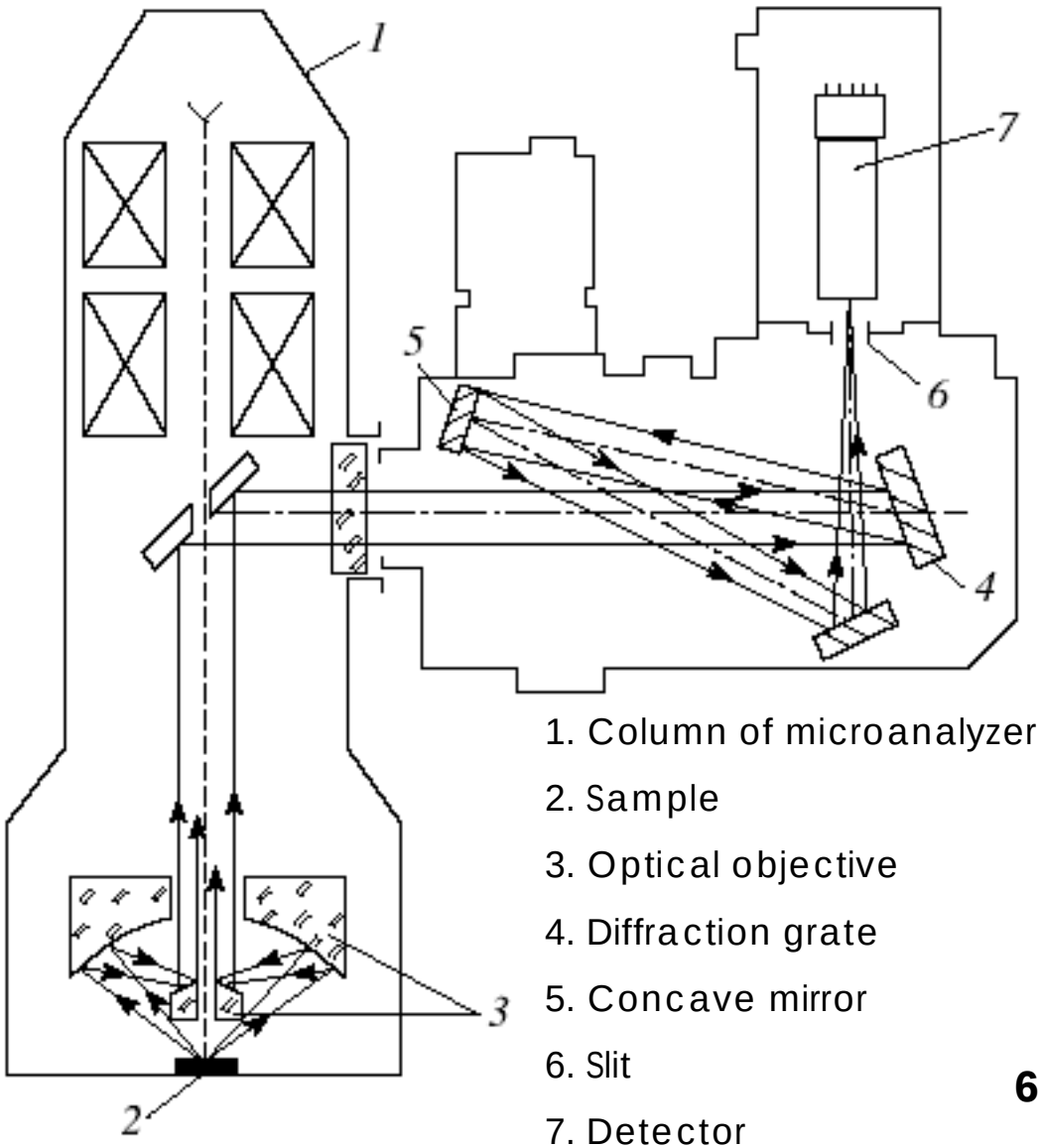
Sample	YAG:Nd monocrystal	YAG:Nd nanoceramics
Photographic images of CL of samples in defocused electron beam		
Nd concentration, at.%	0,15	0,11

Samples


Experiment
Approximation
CL intensity, arb. units
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,00
0,15
0,30
0,45
0,60
0,75
0,90
1,05
Nd concentration, at.%

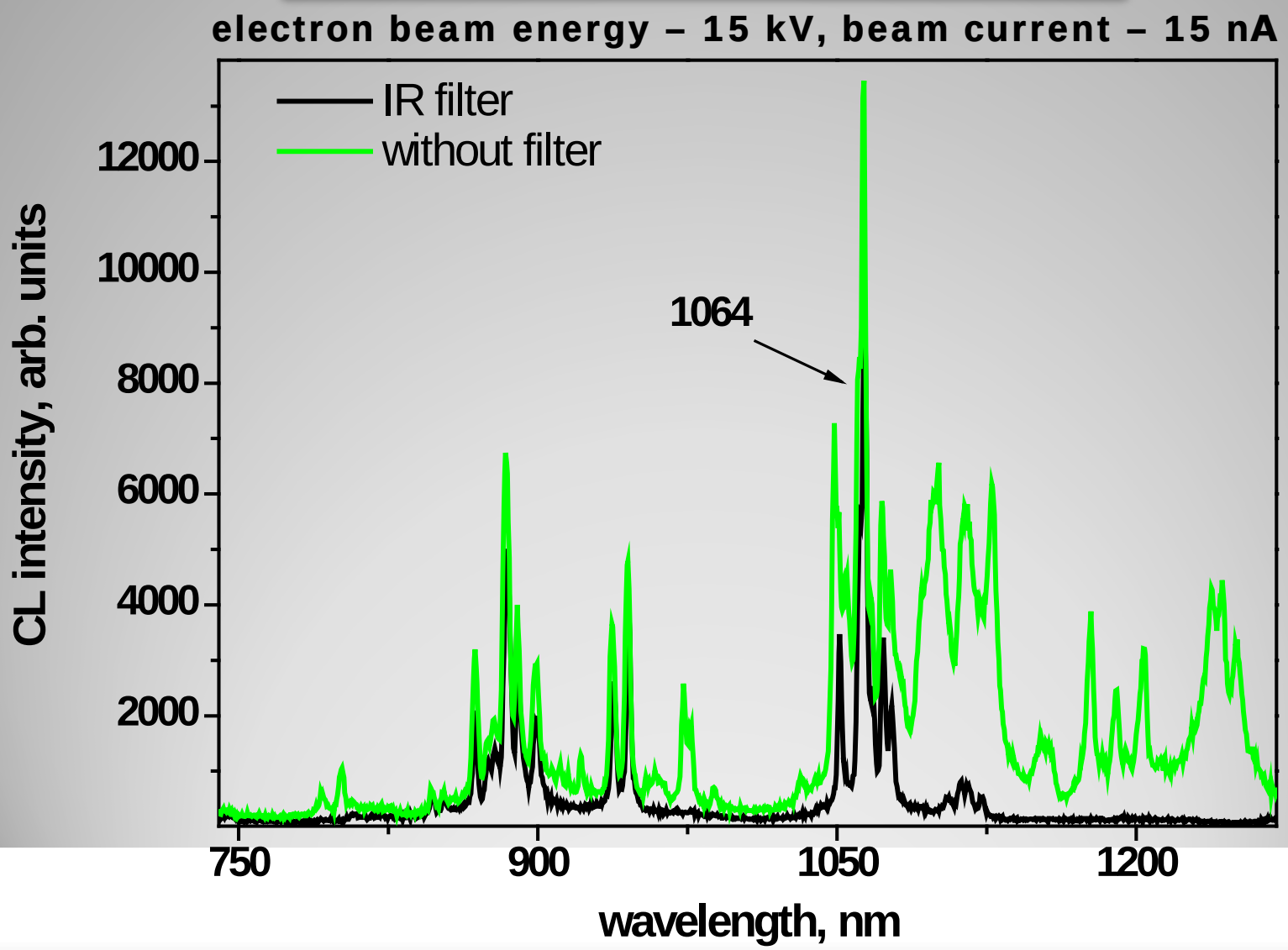
Experimental set





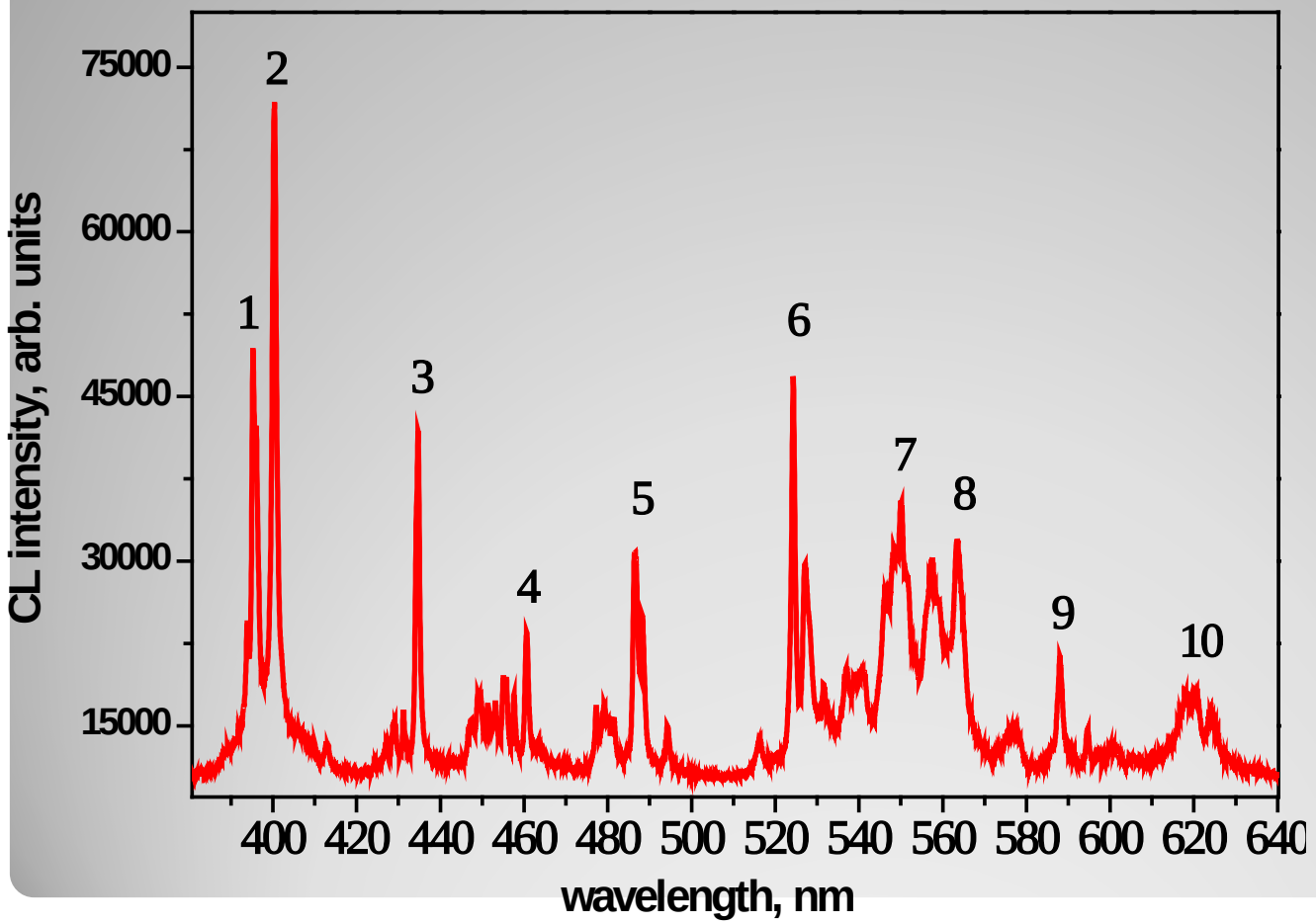
1. Column of microanalyzer
2. Sample
3. Optical objective
4. Diffraction grate
5. Concave mirror
6. Slit
7. Detector

CL spectra (IR range)



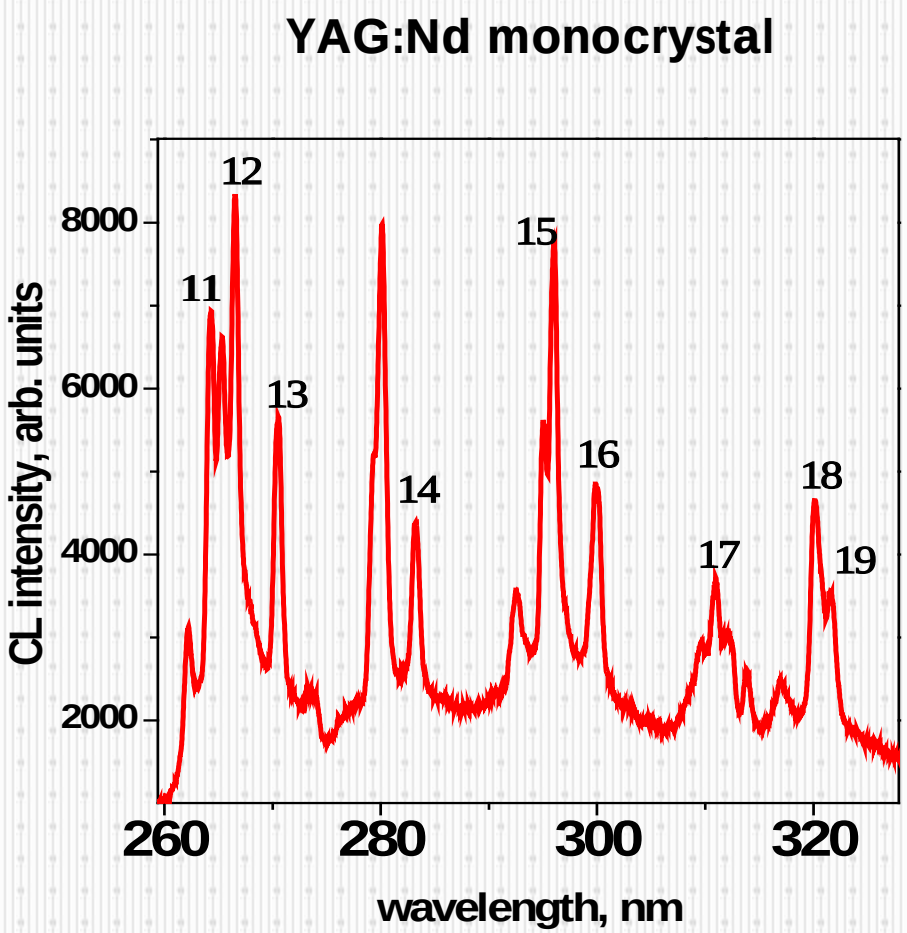
CL spectra (visible range)

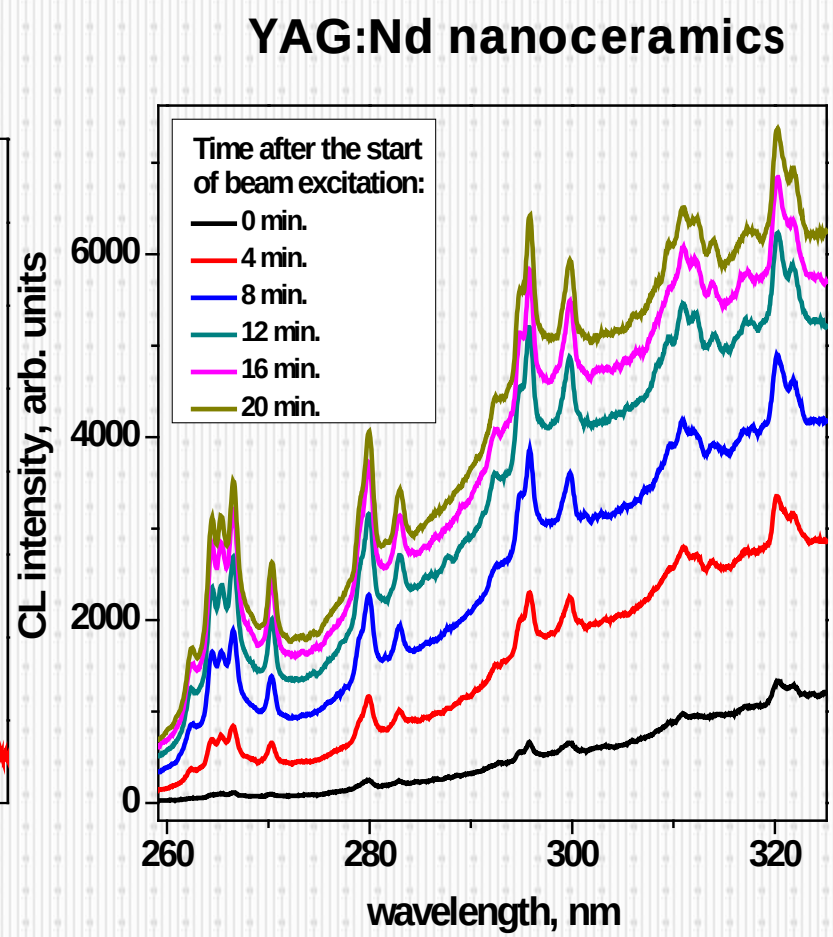
electron beam energy – 15 kV, beam current – 15 nA



CL band	λ, nm
1	396,1
2	401,1
3	435,6
4	461,5
5	489,1
6	525,0
7	550,8
8	564,3
9	588,7
10	621,2

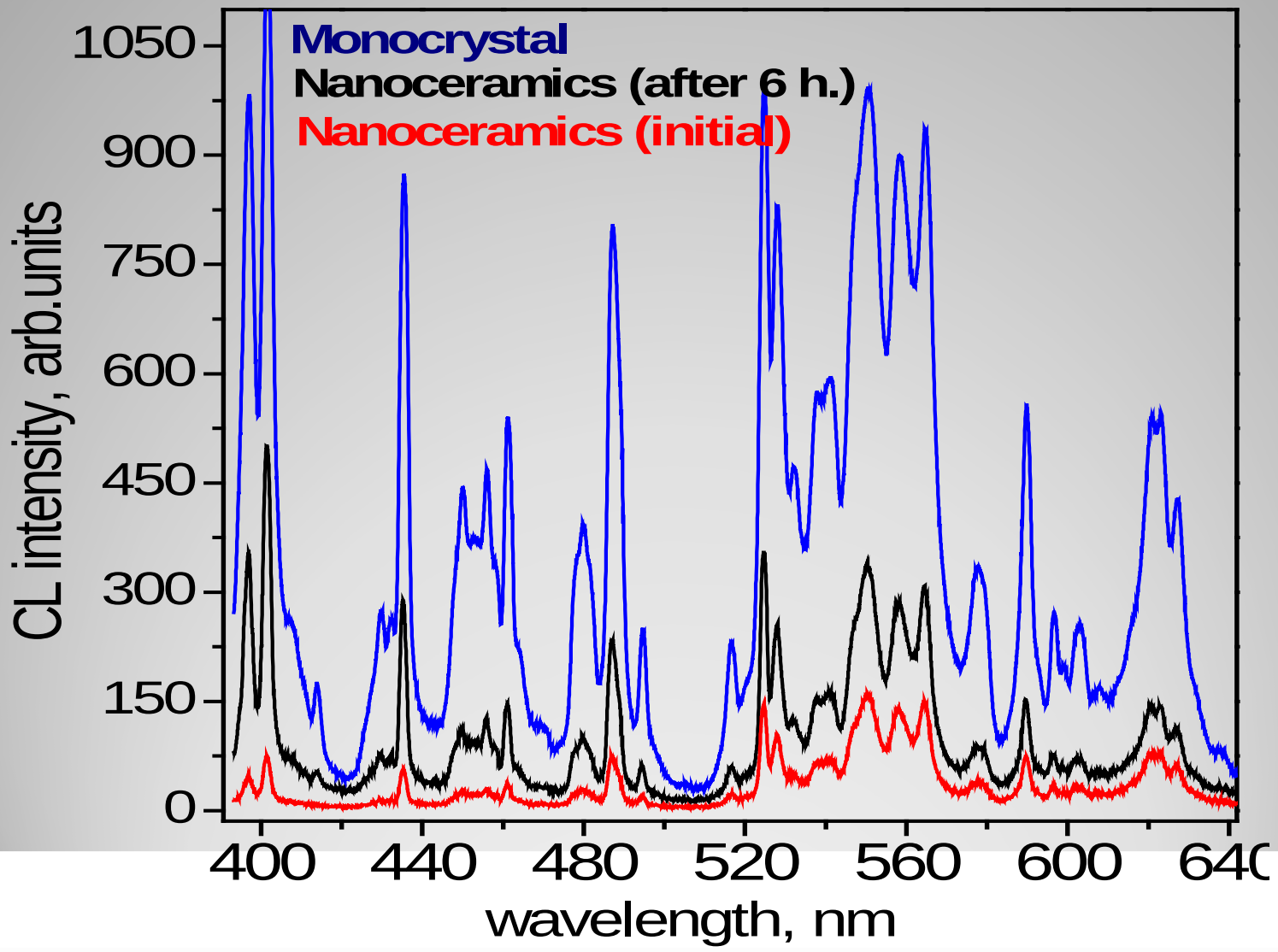
CL spectra (UV range)





CL band	11	12	13	14	15	16	17	18	19
λ, nm	264,8	267,1	270,1	283,7	296,5	300,6	314,4	320,6	322,2

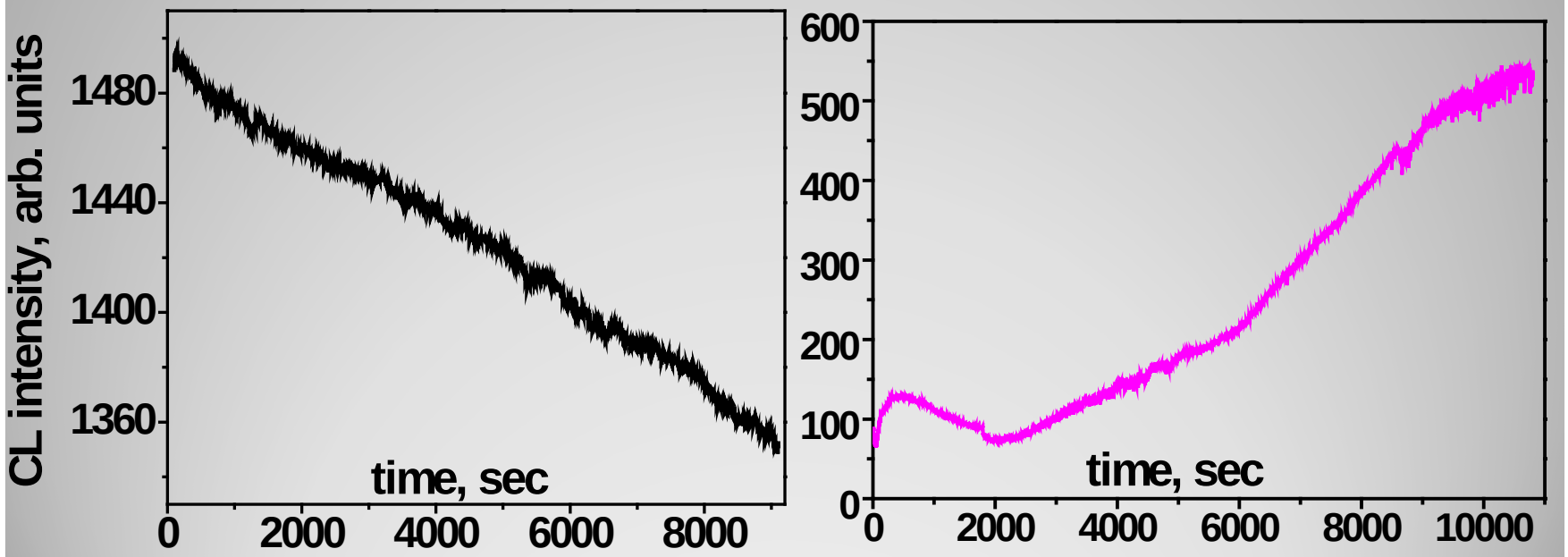
Degradation of CL



Degradation of CL

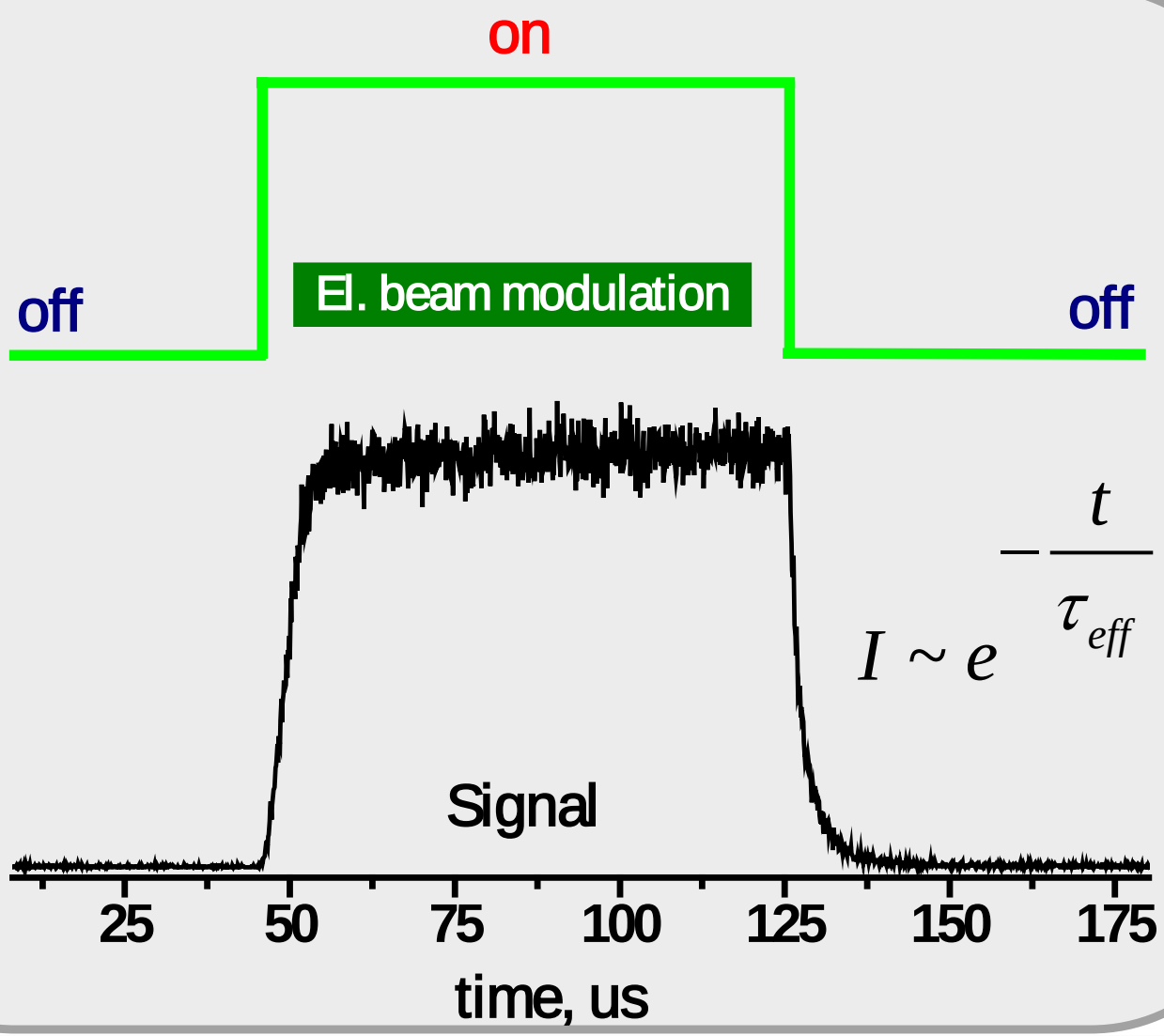
YAG:Nd monocrystal, 2,5 hours

YAG:Nd nanoceramics, 3 hours



Behavior of CL intensity of samples in visible range under continuous irradiation of electron beam

Decay times measurement

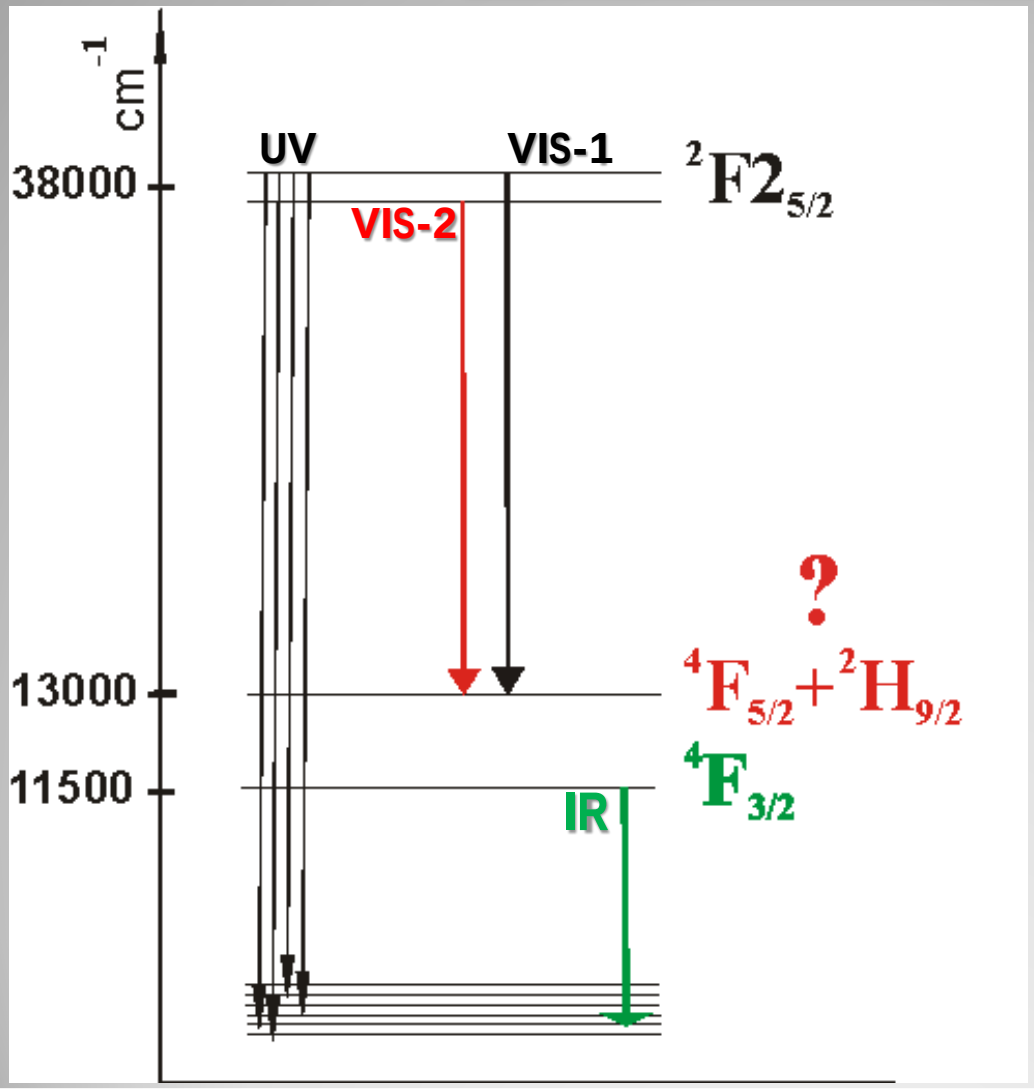


$$I \sim e^{-\frac{t}{\tau_{eff}}}$$

Decay times

YAG:Nd monocrystal		YAG:Nd nanoceramics
CL band (λ,nm)	τ_{eff}, μs	τ_{eff}, μs
1 (396,1)	3,6	
2 (401,1)	3,6	2,4
3 (435,6)	3,6	
4 (461,5)	3,5	
5 (489,1)	3,5	
6 (525,0)	3,6	
7 (550,8)	3,9	2,5
8 (564,3)	3,9	
9 (588,7)	3,8	
11 – 19 (UV)	3,6	
20 (1064)	172,9	87,3

Discussion



YAG:Nd monocrystal	
CL band	τ_{eff}, μs
	3,6
401,1	3,6
	3,6
	3,5
	3,5
	3,5
550,8	3,9
564,3	3,9
588,7	3,8
264,8–322,2 (UV)	3,6
1064 (IR)	172,9

**Comparative analysis of Nd^{3+} (4f) energy levels in four garnet hosts, Physical review B, vol.41, num.12 ,7999-8012 (1990)*

Conclusions

- **The CL spectra** of YAG:Nd in visible diapason **was studied**, **the decay times** of CL bands **were measured**
- It was found that **the decay time for a range of CL bands differ**. **The scheme of transitions** that may explain such an effect **was described**
- **The rise of CL intensity** of bands in nanoceramics **was explored**

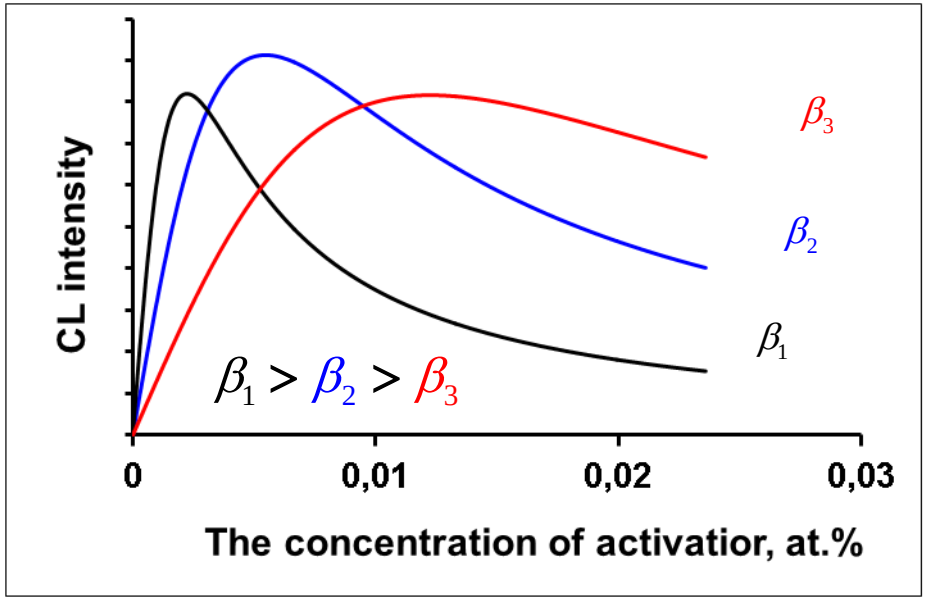
Significant increase of CL in nanoceramics *and its low cost way of preparation may substitute YAG:Nd monocrystal in some applications (scintillators).*

Thank you for attention!

Concentration dependence

∢ Two level system

$$I \sim n_1 = \frac{LJN}{LJ + \tau_{изл}^{-1} + \beta N^{S/3} + \gamma}$$



I - CL intensity

n_1 - concentration of the excited state

J - density of the electron beam

L - efficiency of CL (proportionality factor)

S - multipolarity of interactions

N - concentration of radiation centers

$\tau_{изл}^{-1}$ - probability of spontaneous transition

β - nonradiative transition rate with assistance of resonant transfer

γ - nonradiative transition rate