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Enhanced photoluminescence quantum yield of Ce^{3+}-doped aluminium-silicate glasses for scintillation application

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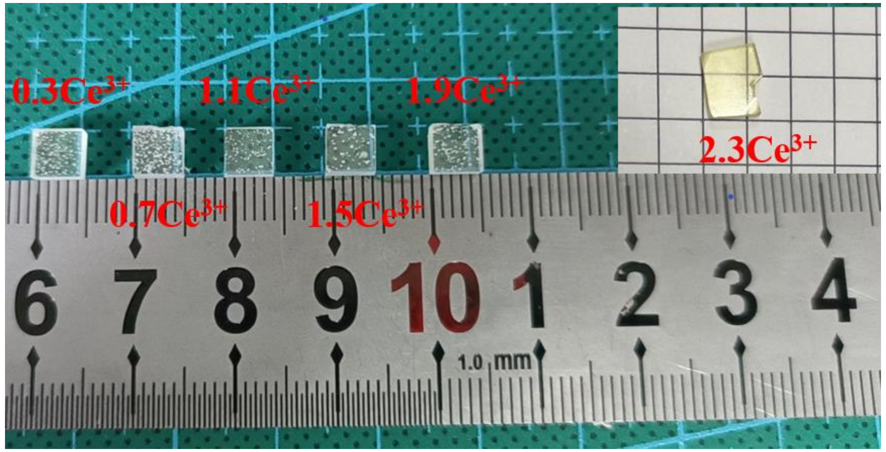
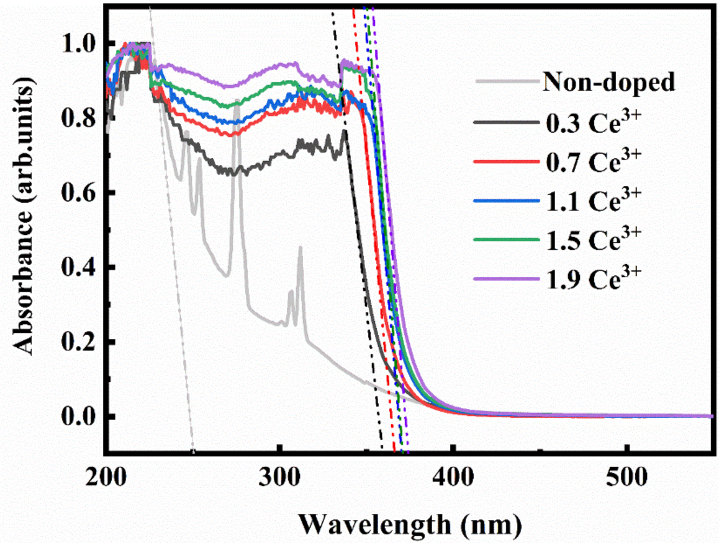
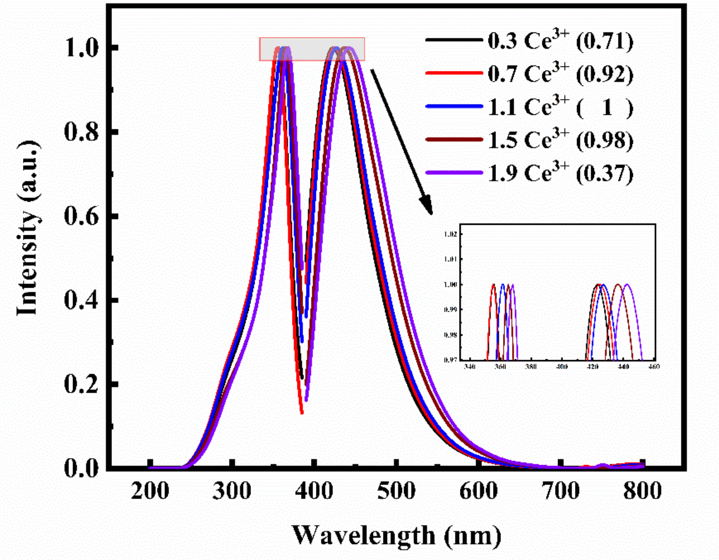
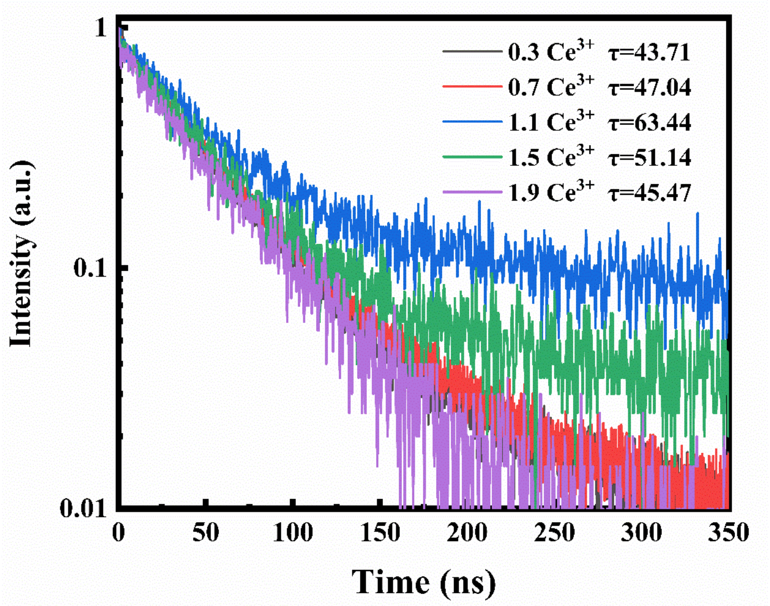
1. Absorption and PL-PLE spectra









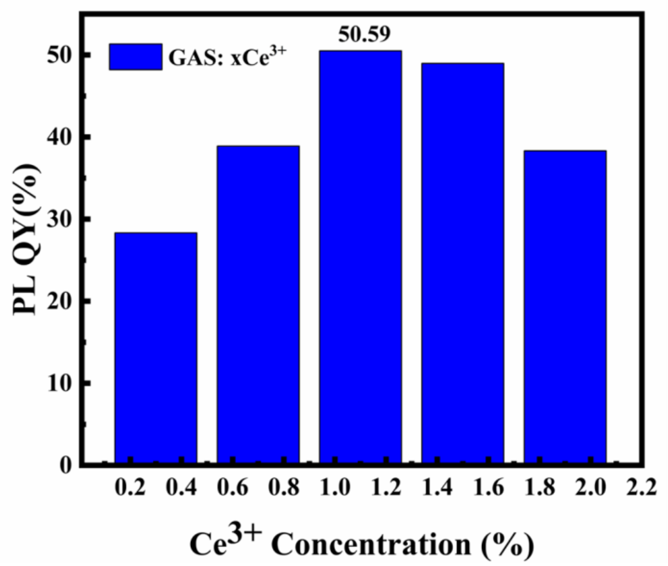
- The cut-off wavelength of the matrix glass is about 250 nm.
- The emission peak, excitation peak and the cut-off wavelength show a red-shift with the increase of Ce^{3+} concentration, because the energy absorbed by the electronic transition gradually becomes weaker.
- PL decay times decrease with further increase of Ce^{3+} ions concentration, which are the typical values for the 5d→4f transition of Ce^{3+} ions.

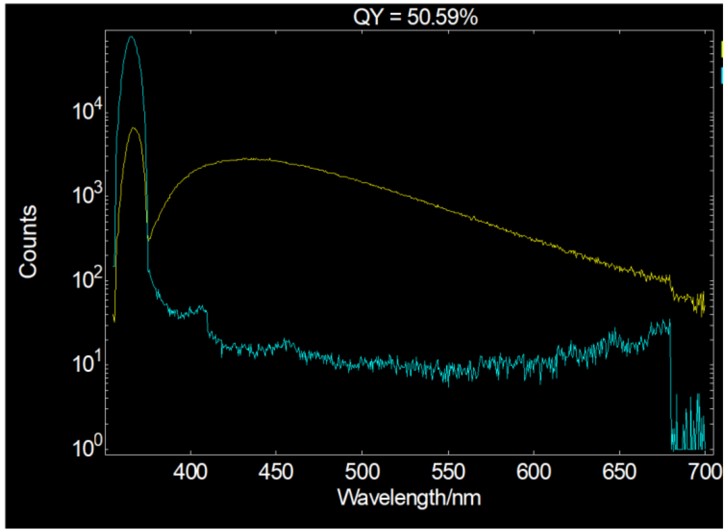
2. PL QY

Glass composition	Density(g/cm^3)	PL QY (%)
Ce^{3+}-Li_3PO_4-B_2O_3	~	15.3
0.5Ce^{3+}-55B_2O_3–20CaO–10Al_2O_3–15La_2O_3	~	42
0.1Ce^{3+}-33.3Li_2O-66.7SiO_2	~	33
0.7Ce^{3+}-34Li_2O–5MgO–10Al_2O_3–51SiO_2 (Commercial GS20)	2.5	~90
0.1Ce^{3+}-40BaO-60B_2O_3	~3.75	40
YAG: Ce^{3+} (as a standard sample)	~	87.22
0.3Ce^{3+}-doped 20Gd_2O_3-20Al_2O_3-60SiO_2	~4.2	28.32
0.7Ce^{3+}-doped 20Gd_2O_3-20Al_2O_3-60SiO_2	~4.2	38.90
1.1Ce^{3+}-doped 20Gd_2O_3-20Al_2O_3-60SiO_2	~4.2	50.50
1.5Ce^{3+}-doped 20Gd_2O_3-20Al_2O_3-60SiO_2	~4.2	48.98
1.9Ce^{3+}-doped 20Gd_2O_3-20Al_2O_3-60SiO_2	~4.2	38.32

$$LY = \frac{E}{\beta E_g} * S * Q$$

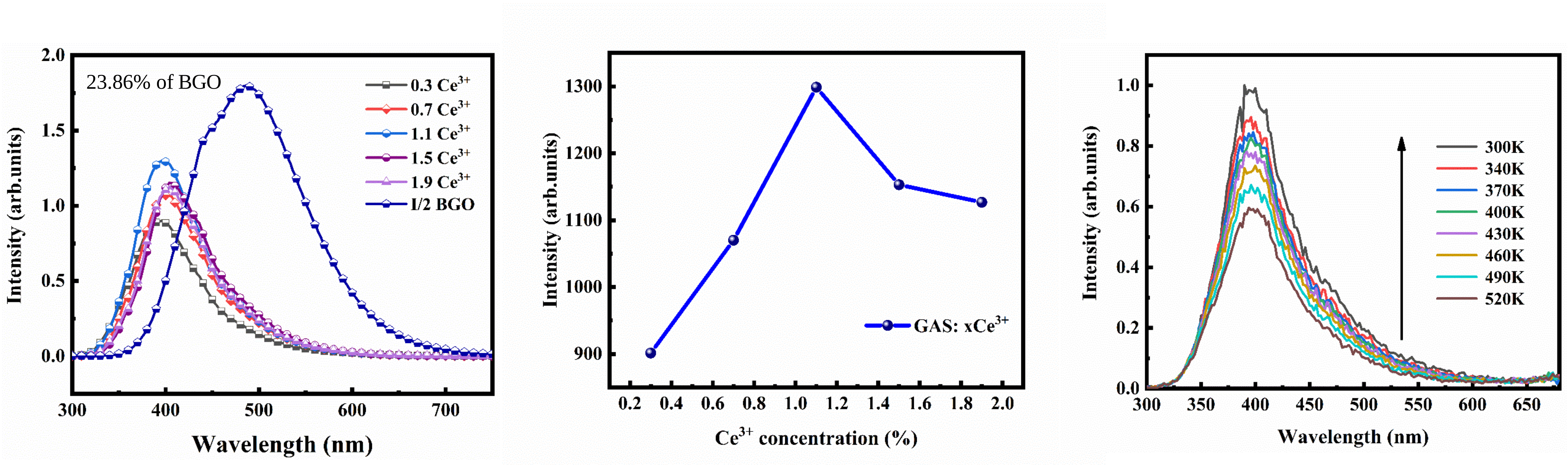
LY—light yield of a scintillator
E—deposited energy of ionizing radiation
β—constant parameter dependent on host material
E_g—band gap energy
S—energy migration
Q—photoluminescence quantum yield





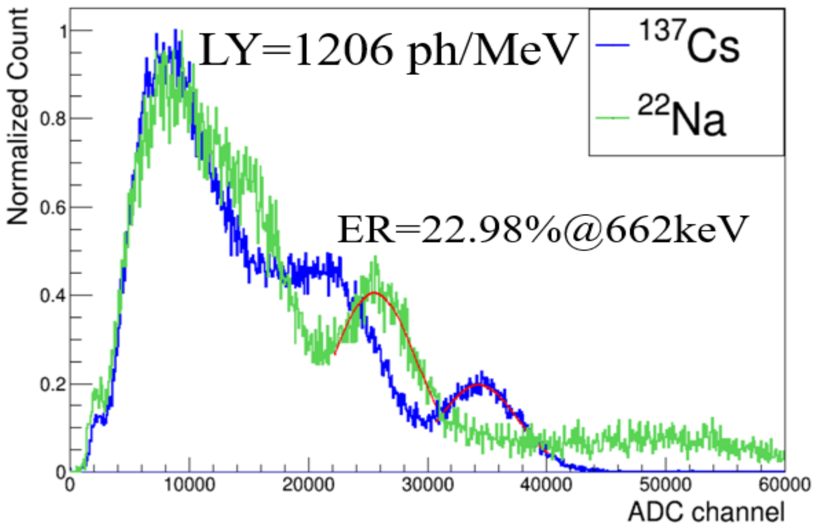
- The PL QYs of GAS: xCe^{3+} glasses first increase and then decrease with the increase of Ce^{3+} concentration, and reach the maximum when x=1.1 mol%.
- When the distance among Ce^{3+} ions exceed a certain threshold, the interaction becomes dominant, resulting in concentration quenching.

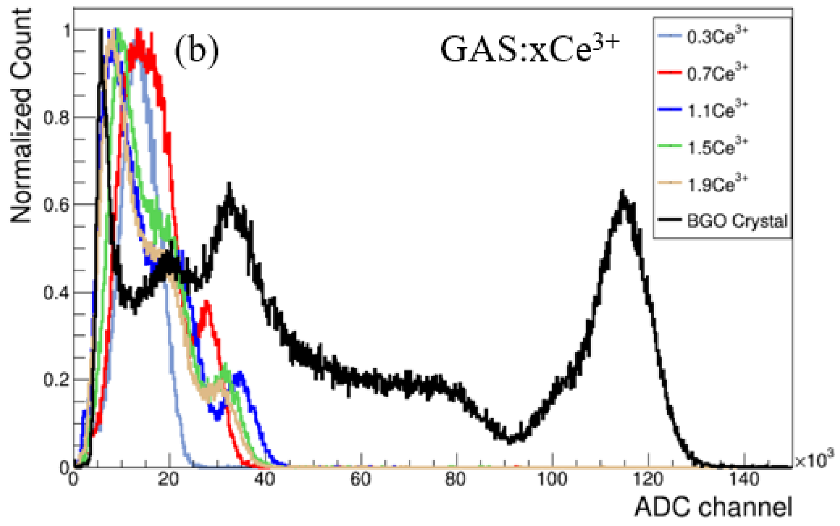
3. XEL and thermal quenching

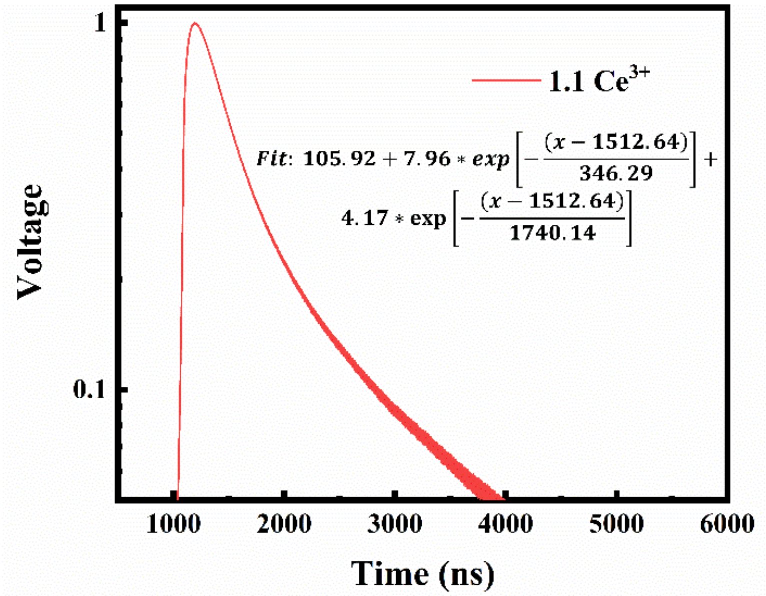


- The emission peak positions of the glasses are different in XEL (390-400 nm) and PL (420-440 nm) spectra due to the difference of the luminescent mechanism and excitation energy.
- The GAS:1.1Ce^{3+} glass shows the highest intensity which is approximately 23.86% that of BGO crystal.
- At 520 K, the luminescent intensity of GAS:1.1Ce^{3+} glass is 59.67% of that of room temperature (300 K), and the thermal quenching in XEL is estimated to be all about 0.14 eV.

4. Gamma-ray scintillation







- The light yield of the GAS: $1.1Ce^{3+}$ glass is calculated to be about 1206 ph/MeV with an energy resolution of 22.98% at 662keV.
- Under the same measurement conditions, the number of photons of glasses detected by SiPM is about 1/4-1/3 of BGO crystal. This result is consistent with change in XEL integral intensity.
- The decay time of the glasses consists of fast and slow components, which are between 395-285 ns and 2332-1382 ns. The fast component originates from the direct capture of electrons by Ce^{3+} ions and the slow component originates from the repeated capture of electrons by defect levels.

Thank you!