Advanced Glass Science
(4016101)

Instructor: Asst.Prof.Dr. Jakrapong Kaewkhao

Course Outline:

Week 5: **Luminescence properties and advanced measurement/calculation analysis**

+

Case studies from international publications

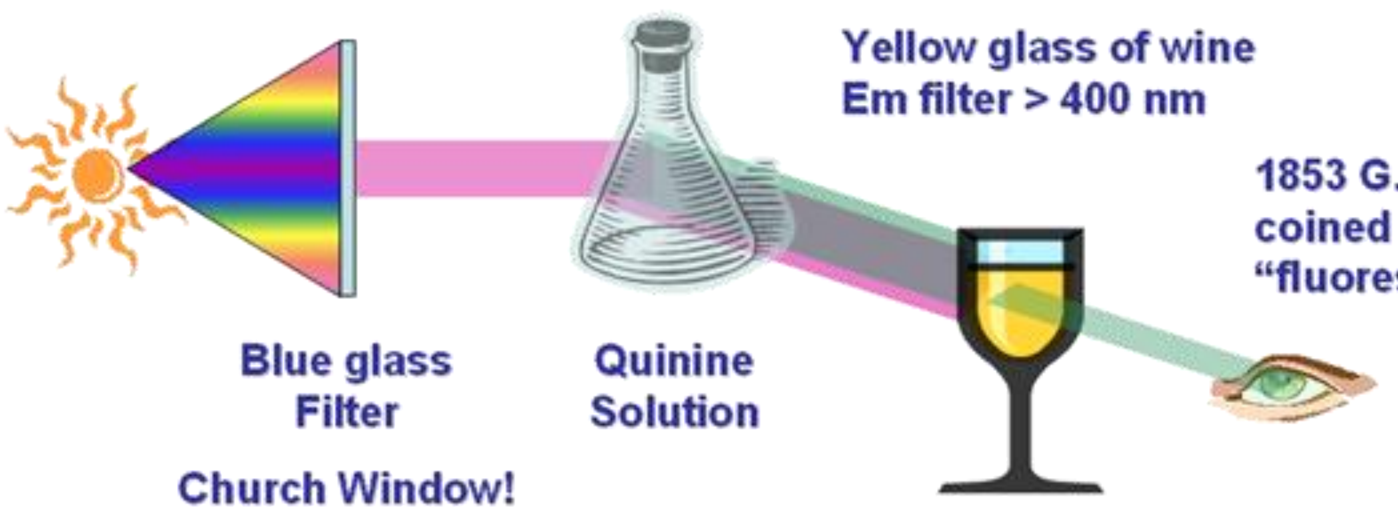
Book: A.K., Varshneya. ***Fundamentals of inorganic glasses***
A., Paul A, ***Chemistry of glasses***
J.E. Shelby, ***Introduction to glass science and technology***

Luminescence

Fluorescence: a type of light emission

- **First observed from quinine by Sir J.F.W. Herschel in 1845**

John Herschel
(1792-1871)



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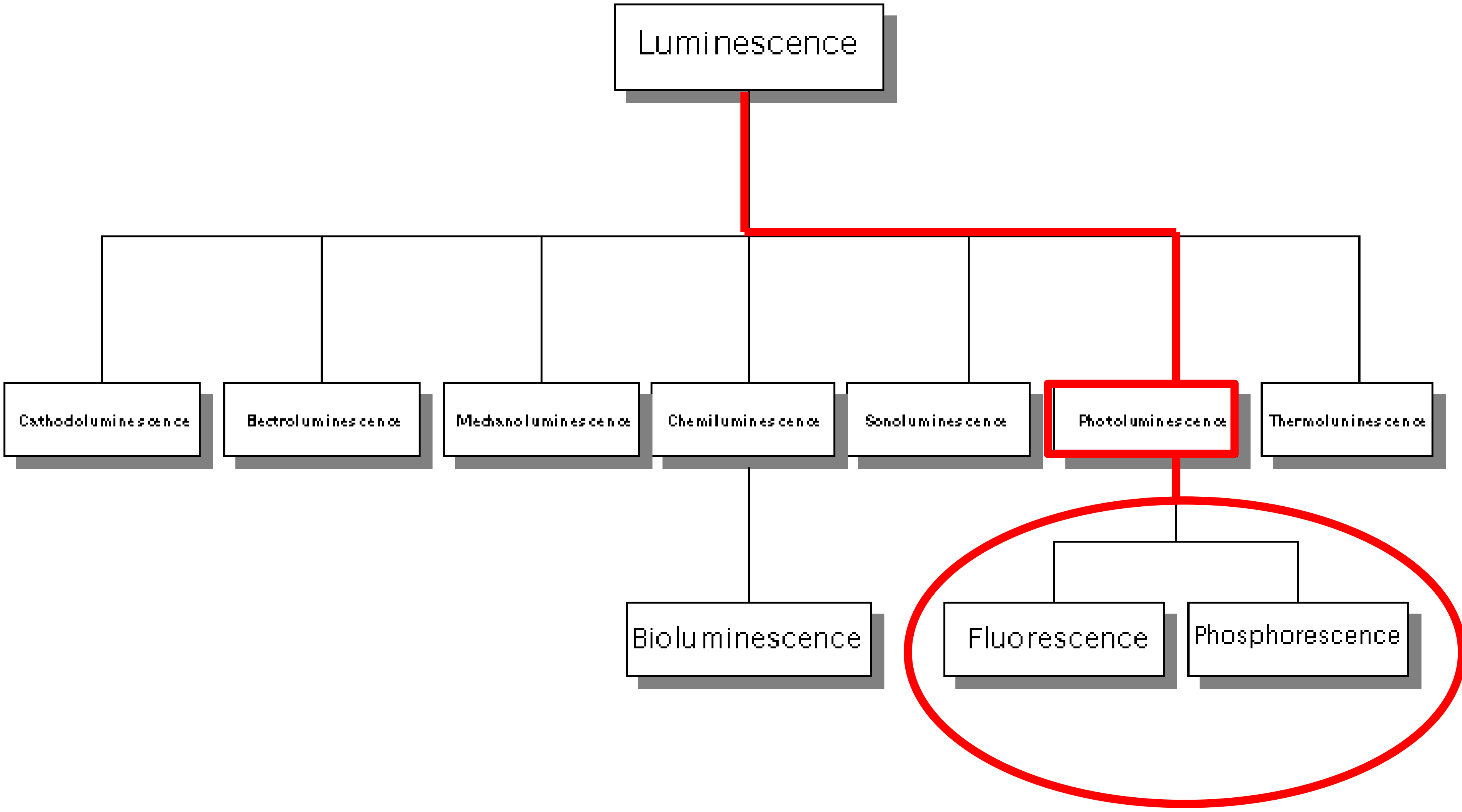
Type of Luminescence



Principle of Photoluminescence

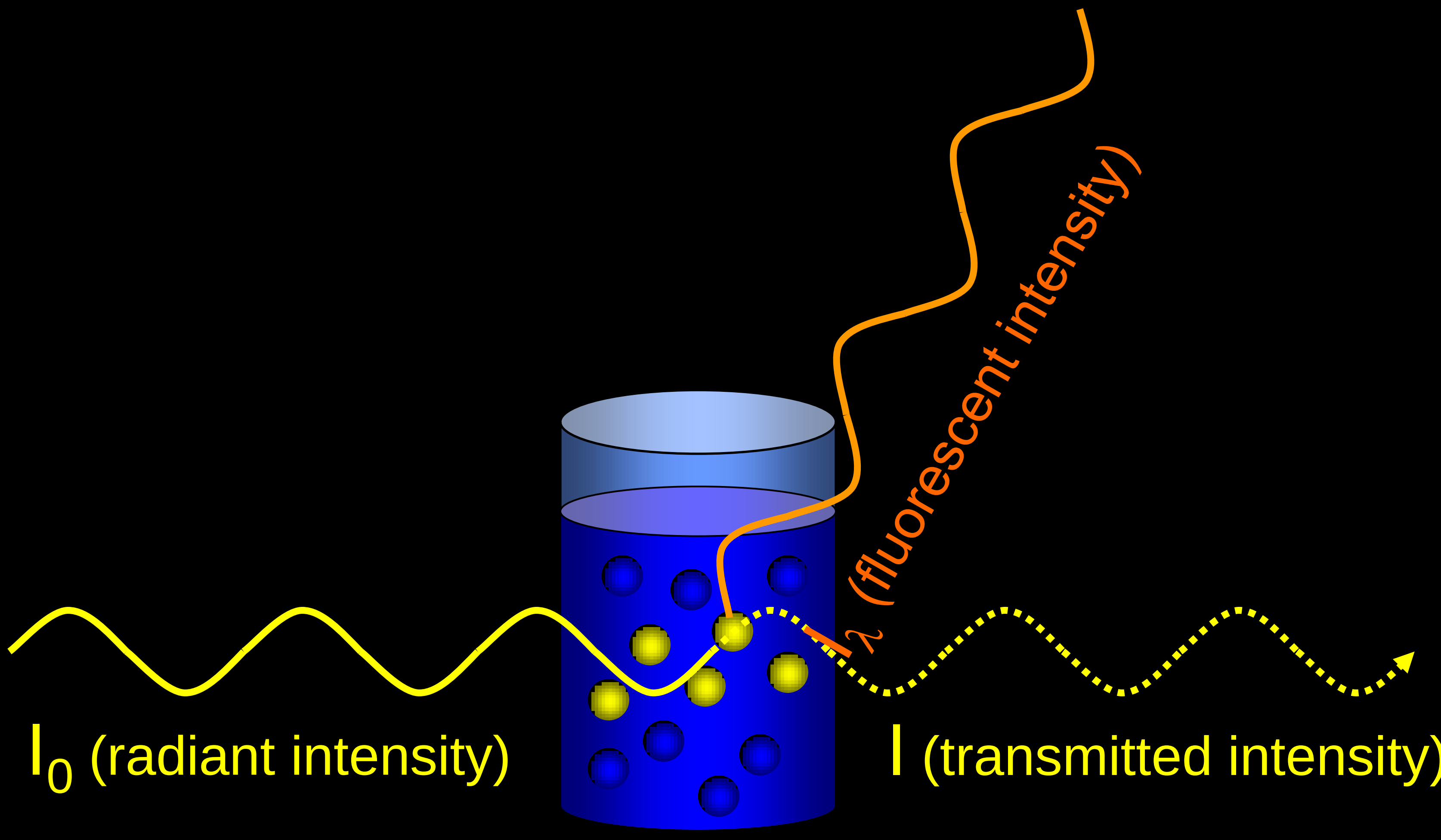
- Chemiluminescence — *excitation resulting from a chemical reaction*
- Phosphorescence — *excitation by absorption of photons:*
- BASIC PRINCIPLE: ***PHOTOLUMINESCENCE***

  1st: molecules are excited (outer shell electrons like in absorbance phenomenon)

  2nd: excited species give an emission spectrum that provides information for quantitation and qualification

Fluorescence is short-lived, with luminescence ceasing almost immediately (<10^{-5} sec) ,while phosphorescence features luminescence from 10^{-4} to several seconds.

What Do We Make Use Of?



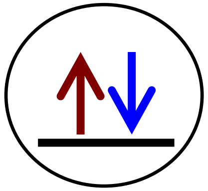
Principle of Photoluminescence

$$^{M}X_{J}$$

$$\mathbf{M = 2S + 1}$$

M = Multiplicity or orbital angular momentum
S = Spin quantum number

Pair electron; $S = (+1/2-1/2) = 0$

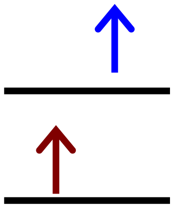


So, $M = 2(0) + 1 = 1$

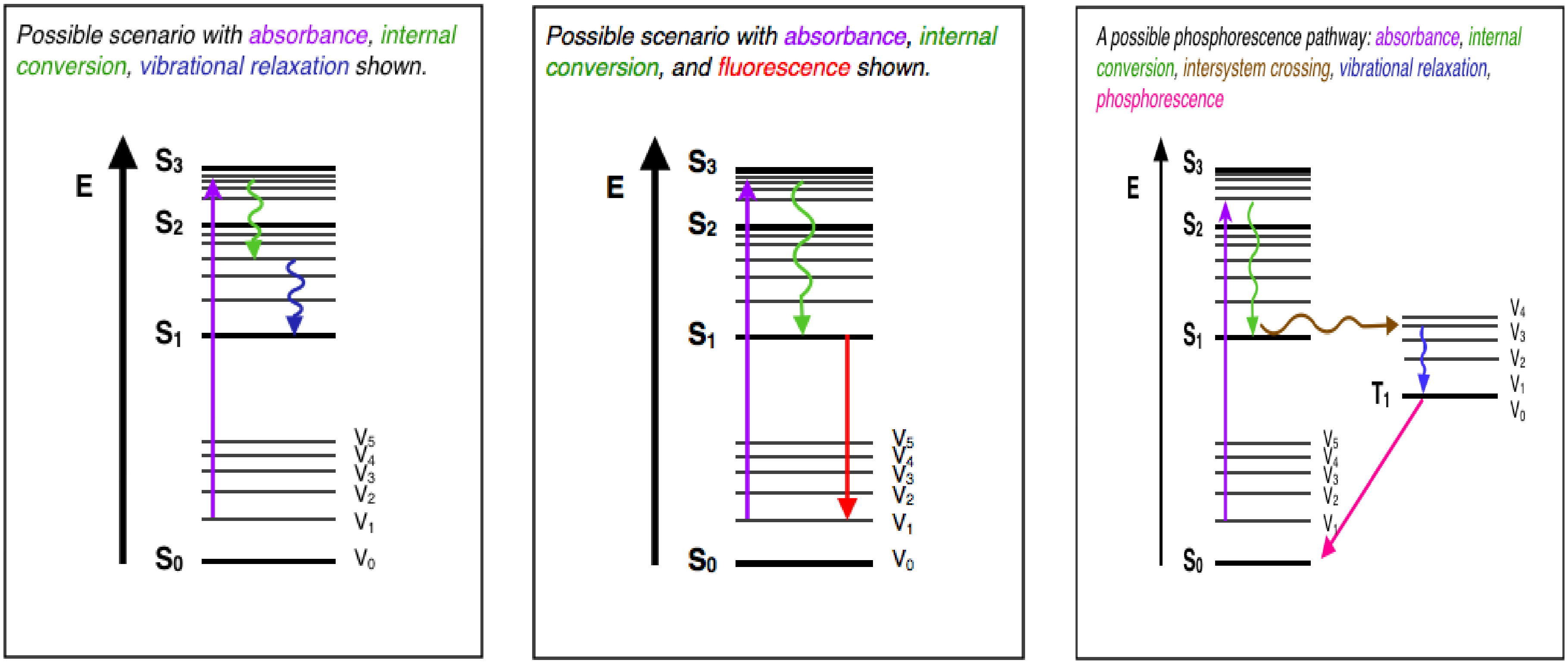
But, while the molecules in the excited state, an electron has a chance to change reverse spin.

$S = (+1/2+1/2) = 1$

So, $M = 2(1) + 1 = 3$



Principle of Photoluminescence



Absorbance Fluorescence Phosphorescence

Fig. 1 Jablonski diagram

Time Scale

Transition	Time Scale (sec)	Radiative process
Absorption	10^{-15}	Yes
Internal conversion	10^{-14} - 10^{-11}	No
Vibrational relaxation	10^{-14} - 10^{-11}	No
Fluorescence	10^{-9} - 10^{-7}	Yes
Intersystem crossing	10^{-8} - 10^{-3}	No
Phosphorescence	10^{-4} - 10^{-1}	yes

Factors Influencing Photoluminescence

- Solvent effects → Frank-Condon principle
- Effect of pH →
  - Different molecule and ion
  - Resonance
- Temperature effect → Internal conversion
- Effect of hydrogen bonding →
  - Reduce Quantum efficiency
  - Internal conversion
- Effect of dissolved oxygen →
  - Oxidation with fluorescence mat.
  - Intersystem crossing
- Effect of impurity → Inner filter effect
- Effect of concentration → Concentration quenching effect

Effect of Concentration

$$I_f \ \alpha \ \Delta I \ \alpha \ (I_o - I_T)$$

$$I_f = \Theta_f(I_o - I_T)$$

I_f = Intensity of fluorescence
I_o = Intensity of initial light
I_T = Intensity of transmitance
Θ_f = Quantum efficiency

From Lambert-Beer law; $I_T = I_o e^{-2.303\varepsilon bc}$

So, $I_f = \Theta_f(I_o - I_o e^{-2.303\varepsilon bc})$

$I_f = \Theta_f I_o(1 - e^{-2.303\varepsilon bc})$

Distribution equation

So, $e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots + \frac{x^n}{n!}$

Effect of Concentration

So, $$I_f = \Theta_f I_o \left[1 - 1 + 2.303\varepsilon bc - \frac{(2.303\varepsilon bc)^2}{2!} + \frac{(2.303\varepsilon bc)^3}{3!} + \ldots + \frac{(2.303\varepsilon bc)^n}{n!} \right]$$

$$I_f = \Theta_f I_o \left[2.303\varepsilon bc - \frac{(2.303\varepsilon bc)^2}{2!} + \frac{(2.303\varepsilon bc)^3}{3!} + \ldots + \frac{(2.303\varepsilon bc)^n}{n!} \right]$$

If the solution dilution, $\varepsilon bc \leq 0.05$

So, $\boxed{I_f = \Theta_f I_o 2.303\varepsilon bc}$ or $\boxed{I_f = KC}$

Where K = Constant for the equipment used

C = Concentration

Effect of Concentration

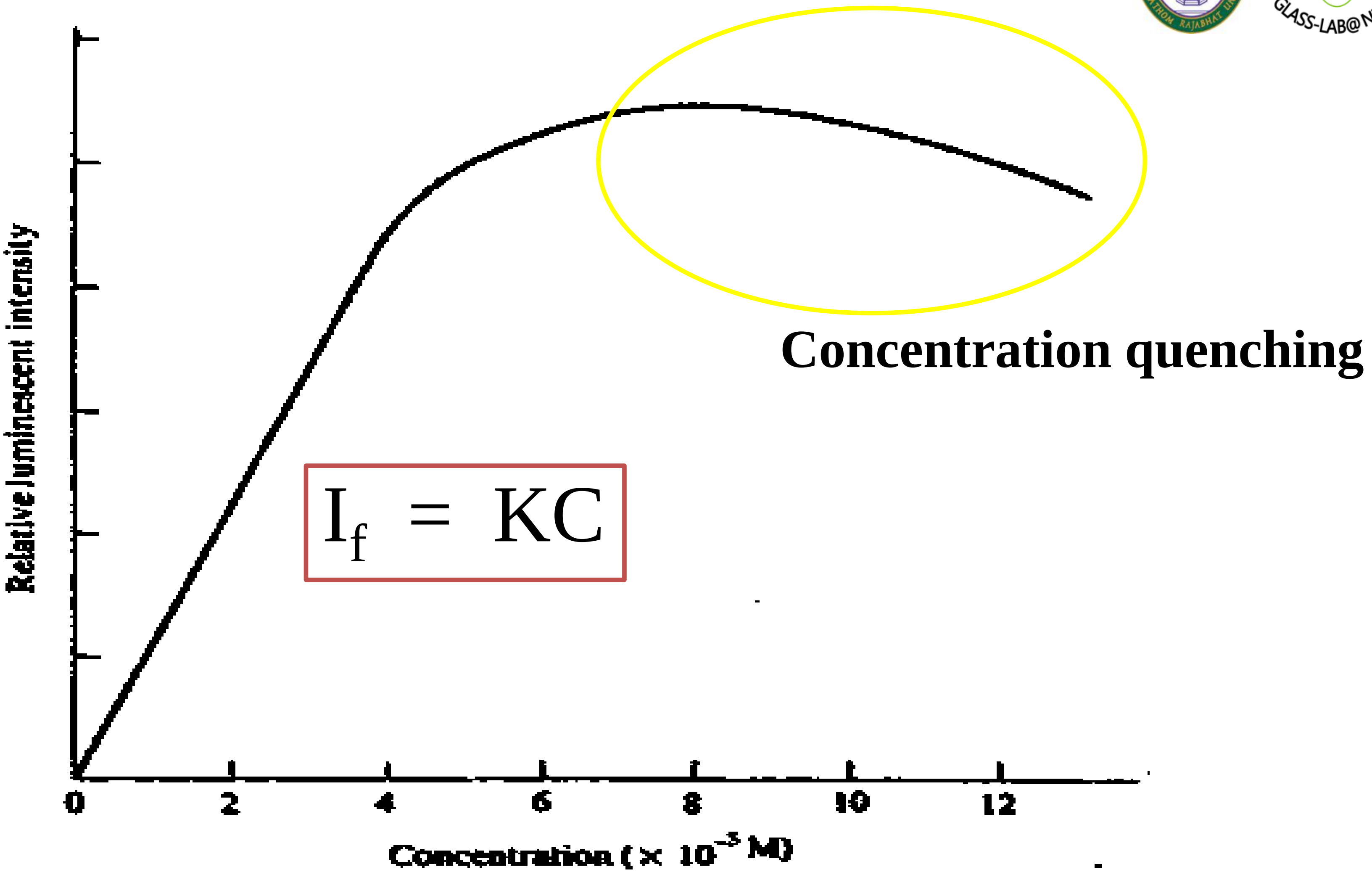


Fig. 2 Relation of concentration and luminescence intensity

Luminescence Measurement

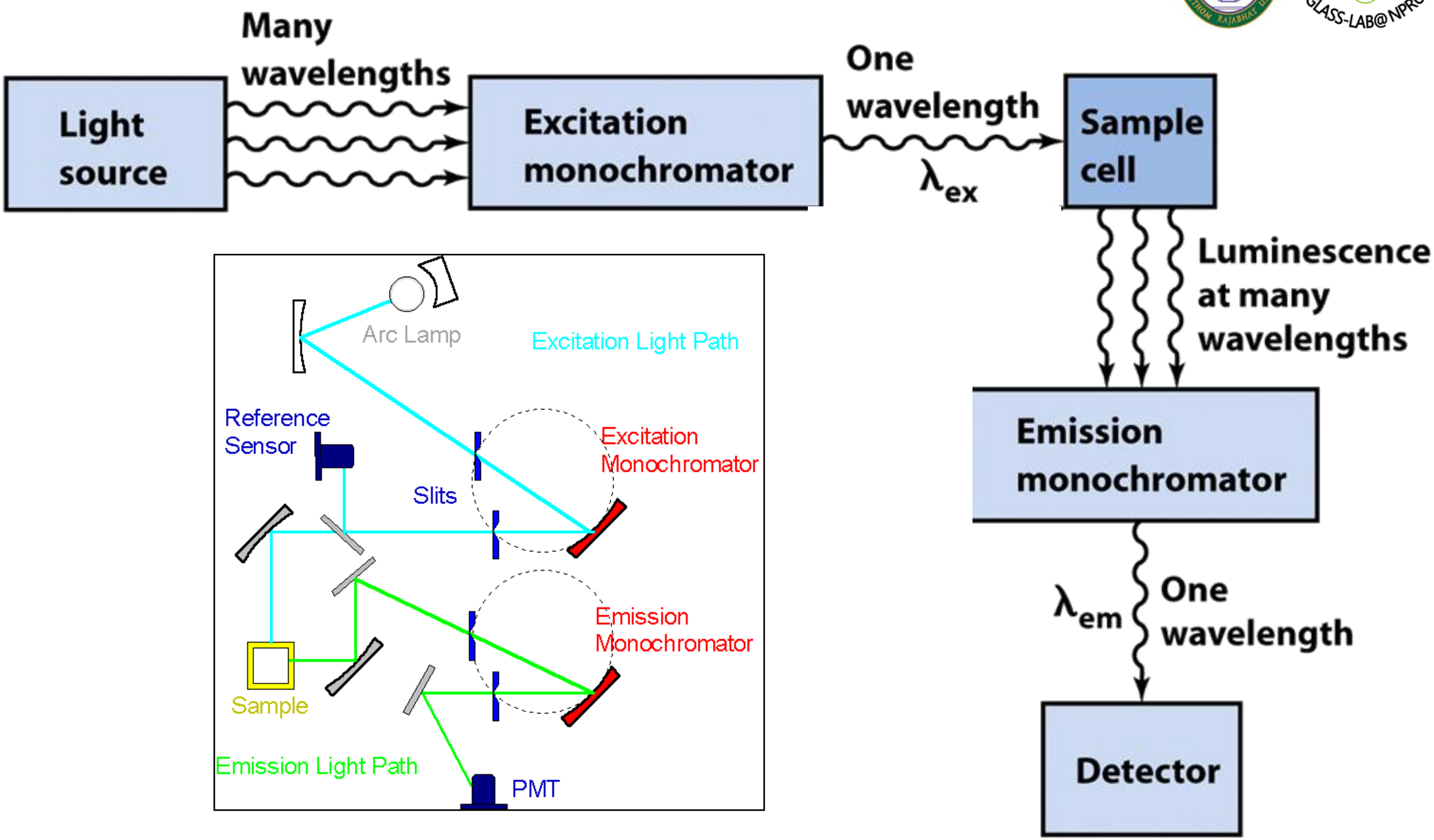


Fig. 3 Luminescence measurement diagram

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The Photoluminescence and Physical Properties of Eu^{3+} Ions in Li_2O-Y_2O_3-B_2O_3 Glass System

E. Kaewnuam[1,a], P. Prongsamrong[1,b], H.J. Kim[2,c], J. Kaewkhao[1,3,d], N. Chanthima[1,3,e*]

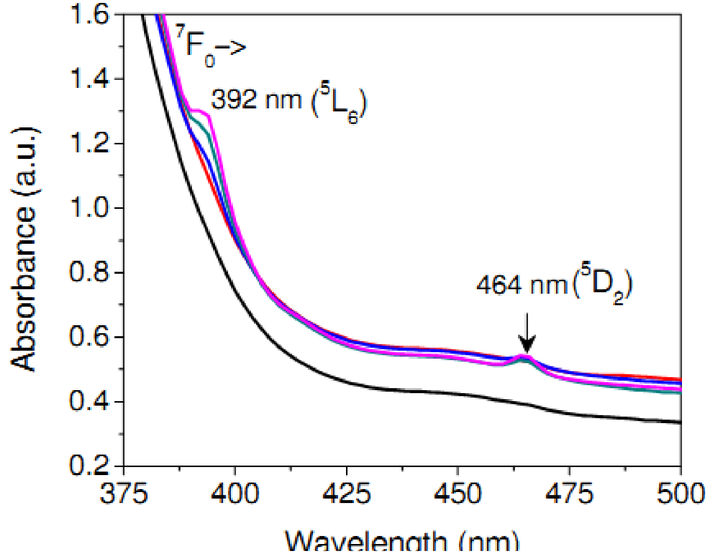

Fig. 4 The optical absorption spectra of LiYBO:Eu^{3+} glass sampleS

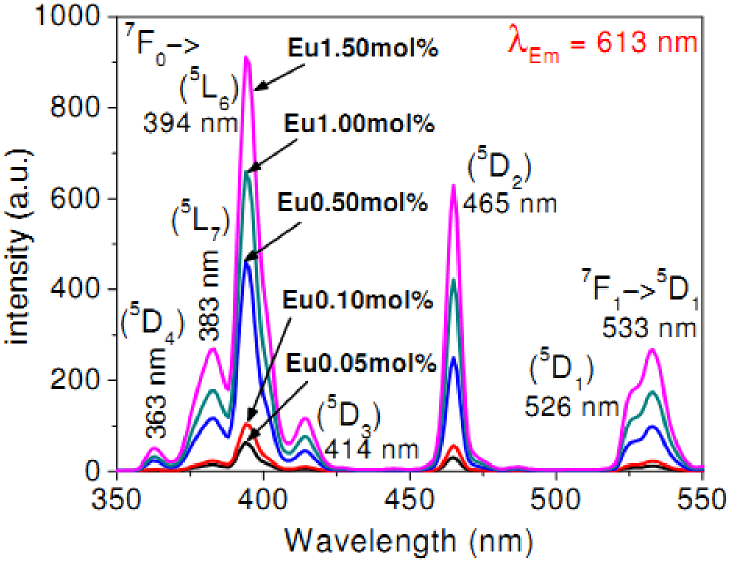

Fig. 5 The excitation spectra of LiYBO:Eu^{3+} glass samples

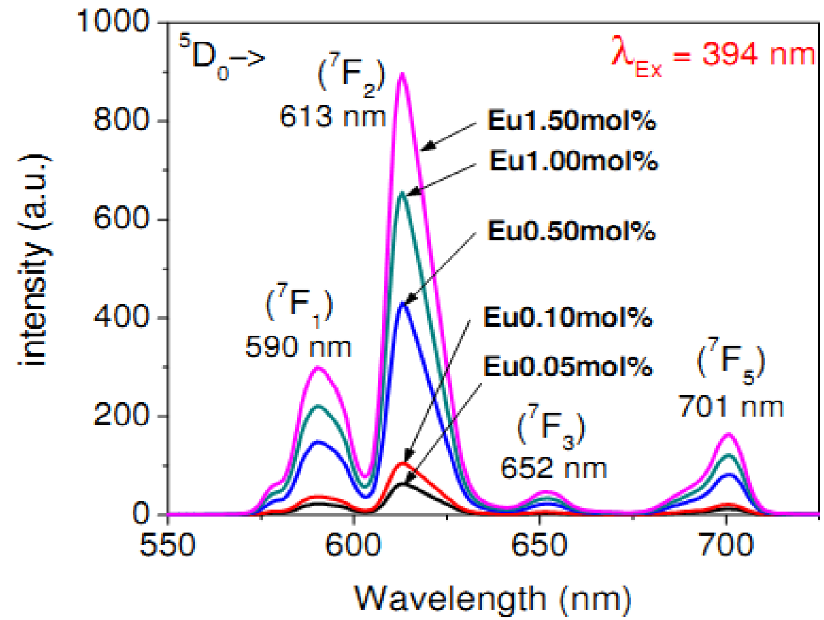

Fig. 6 The emission spectra of LiYBO:Eu^{3+} glass samples

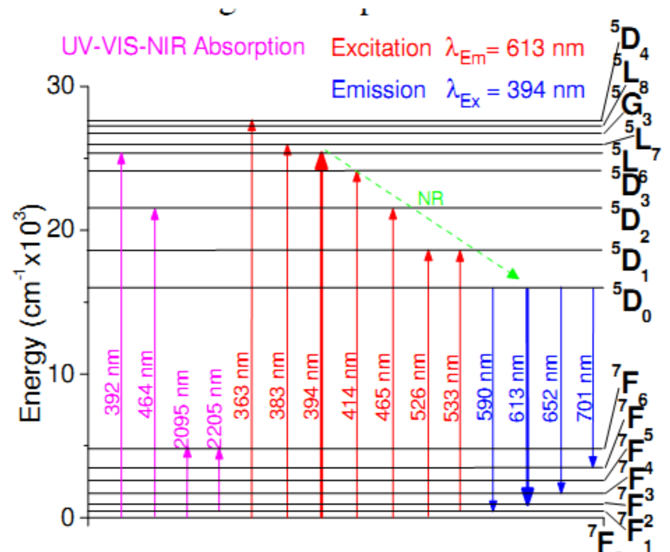

Fig. 7 Energy level of LiYBO:Eu^{3+} glass samples

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doi:10.4028/www.scientific.net/AMR.979.171

The Photoluminescence, Optical Absorption and Physical Properties of Dy^{3+} Ions in Li_2O-La_2O_3-B_2O_3 Glass System

N. Wantana[1,a], H.J. Kim[2,b], O. Chamlek[1,c], J. Kaewkhao[3,4,d], N. Chanthima[3,4,e*]

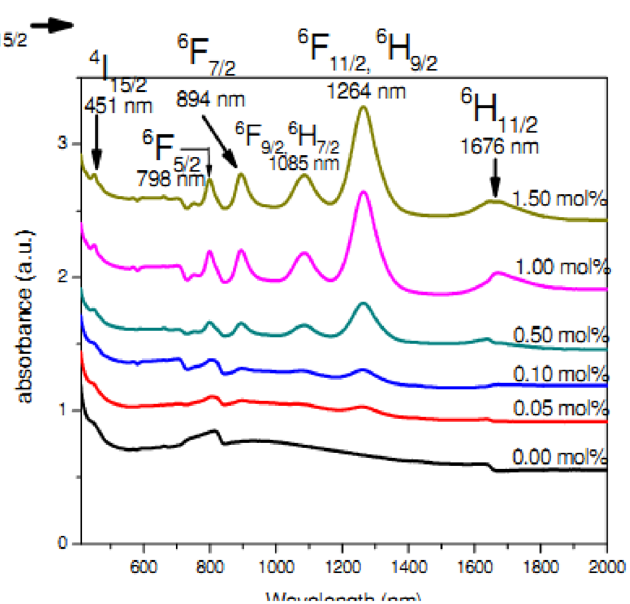

Fig. 8 The optical absorption spectra of LiLaBO:Dy^{3+} glass samples

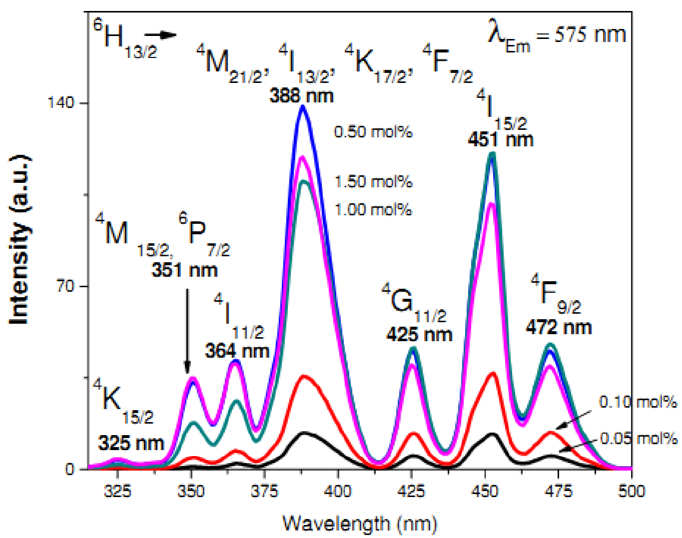

Fig. 9 The excitation spectra of LiLaBO:Dy^{3+} glass samples

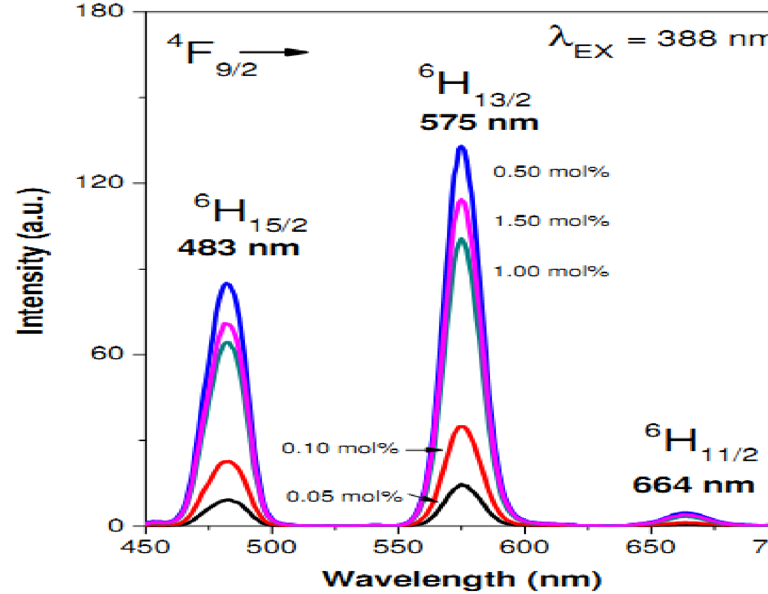

Fig. 10 The emission spectra of LiLaBO:Dy^{3+} glass samples

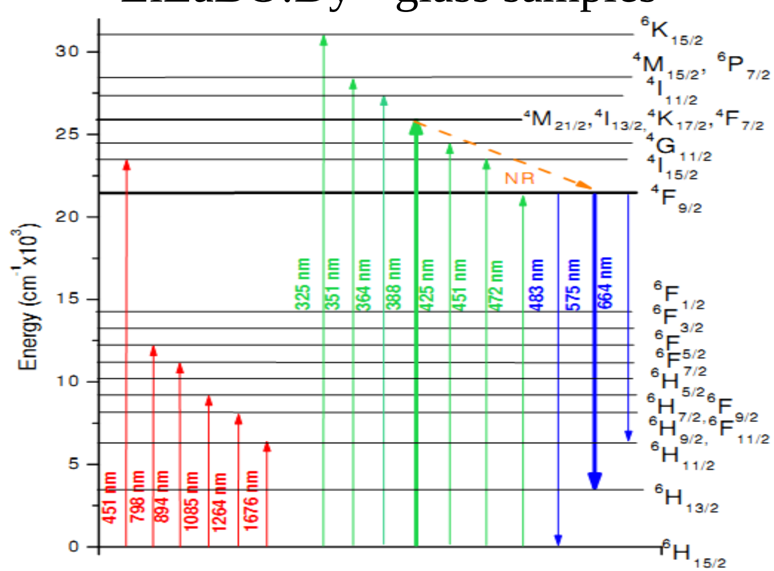

Fig. 11 Energy level of LiLaBO:Dy^{3+} glass samples

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doi:10.4028/www.scientific.net/AMR.979.280

Optical Absorption and Photoluminescence Properties of Dy^{3+} Ions in Bi_2O_3-SiO_2-B_2O_3 Glass System

N. Sangwaranatee[1,a], Y. Tariwong[1,a], S. Sarachai[1,a], J. Kaewkhao[2,3,b], N. Chanthima[2,3,c*]

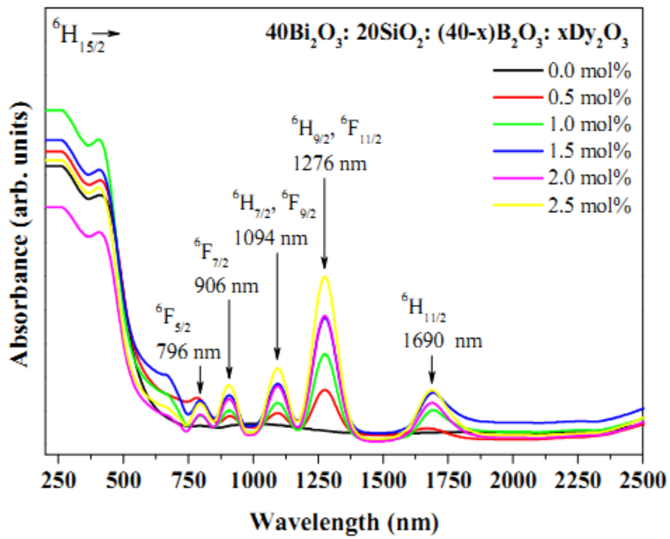

Fig. 12 The optical absorption spectra of Dy^{3+} doped in bismuth borosilicate glasses

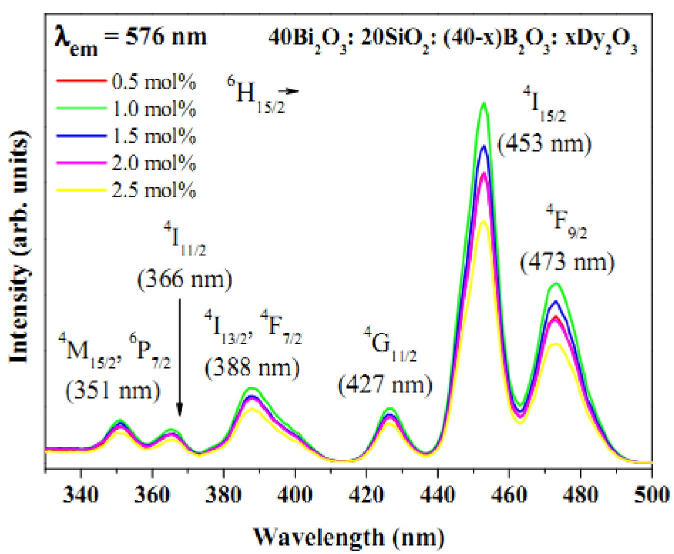

Fig. 13 The excitation spectra of Dy^{3+} doped in bismuth borosilicate glasses

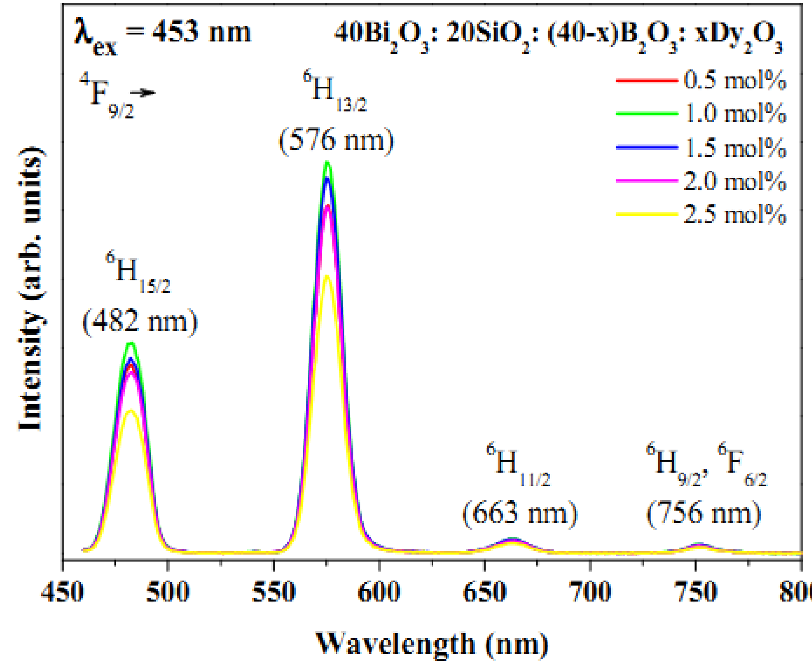

Fig. 14 The emission spectra of Dy^{3+} doped in bismuth borosilicate glasses

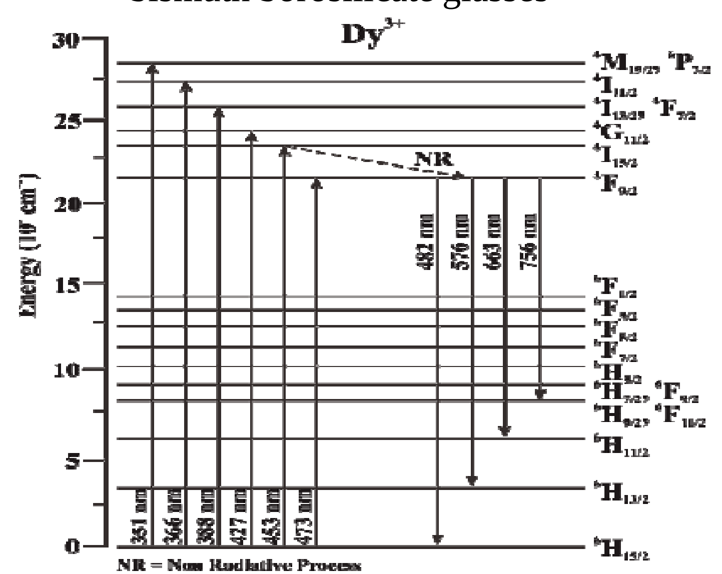

Fig. 15 Energy level of LiLaBO:Dy^{3+} doped in bismuth borosilicate glasses

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doi:10.4028/www.scientific.net/AMR.979.479

Luminescence and Optical Properties of Li_2O_3:Gd_2O_3:B_2O_3:Sm_2O_3 Glasses System

W. Sa-ardsin[1,a], P. Yasaka[2,b], J. Kaewkhao[1,2,c], K. Boonin[1,2,d*]

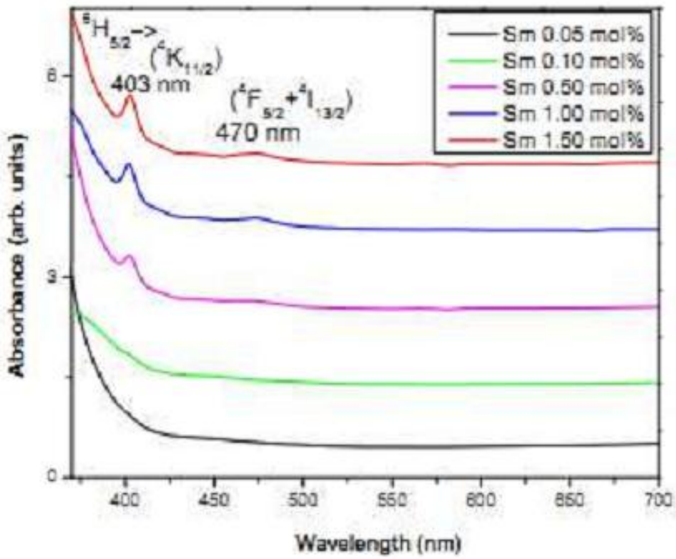

Fig. 16 The optical absorption spectra of LGBOBO:Eu^{3+}glass samples

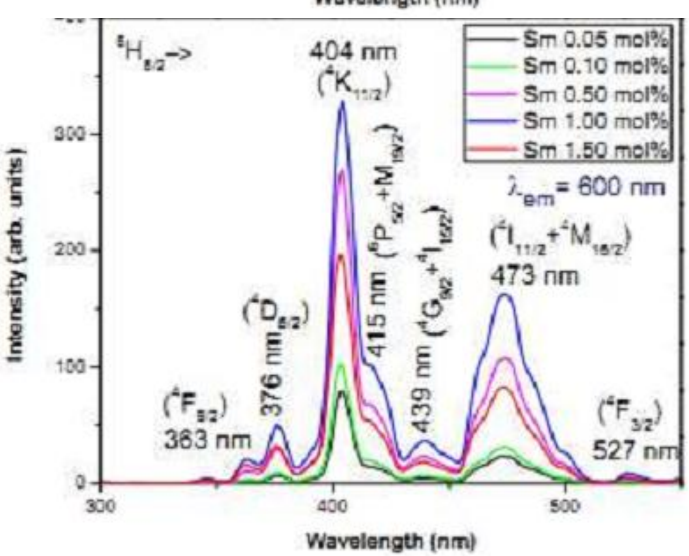

Fig. 17 The excitation of LGBO:Eu^{3+}glass samples

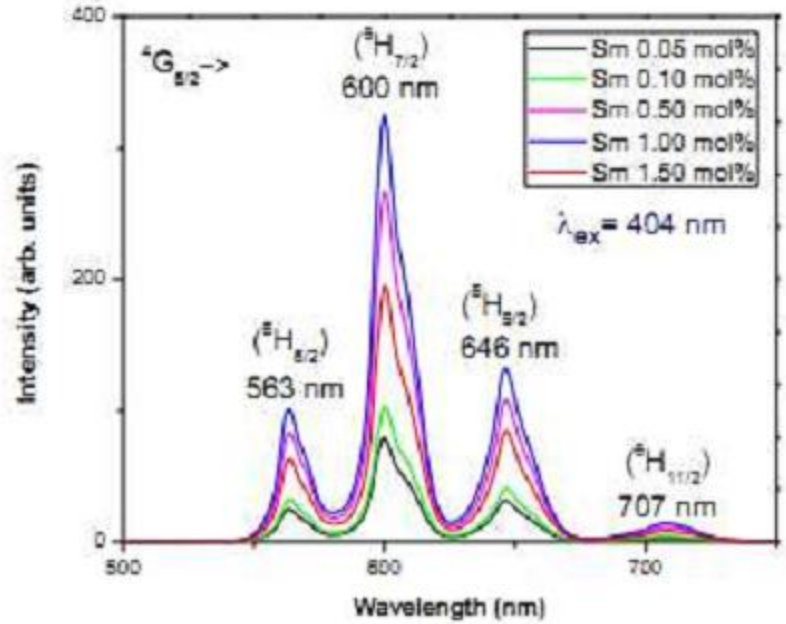

Fig. 18 The emission spectra of LGBO:Sm^{3+} glass samples

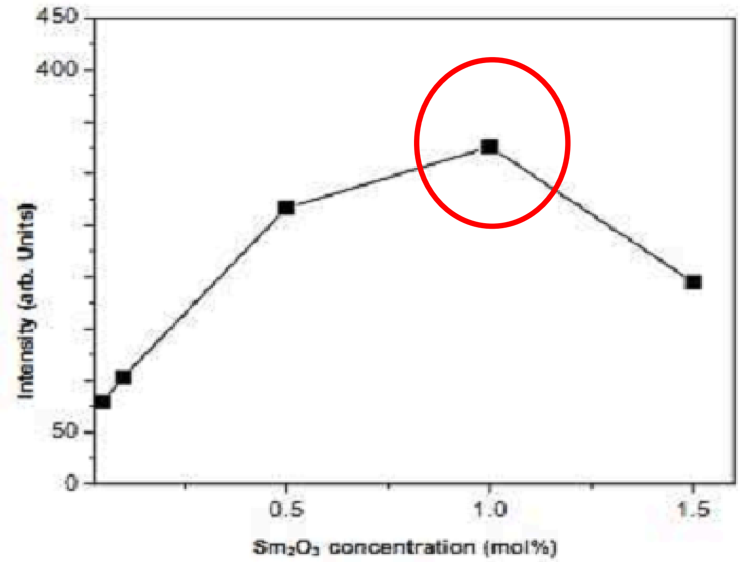

Fig. 19 Concentration quenching of LGBO:Sm^{3+} glass samples

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Research Article

Up- and Downconversion Luminescence Properties of Nd^{3+} Ions Doped in Bi_2O_3–BaO–B_2O_3 Glass System

R. Ruamnikhom,[1] P. Limsuwan,[1] M. Horprathum,[2] N. Chanthima,[3] H. J. Kim,[4] S. Ruengsri,[5] and J. Kaewkhao[3]

Nd_2O_3 (mol%)	Glass system
0.00	$40.00Bi_2O_3 : 20.00BaO : 40.00B_2O_3$
0.50	$40.00Bi_2O_3 : 20.00BaO : 39.50B_2O_3 : 0.50Nd_2O_3$
1.00	$40.00Bi_2O_3 : 20.00BaO : 39.00B_2O_3 : 1.00Nd_2O_3$
1.50	$40.00Bi_2O_3 : 20.00BaO : 38.50B_2O_3 : 1.50Nd_2O_3$
2.00	$40.00Bi_2O_3 : 20.00BaO : 38.00B_2O_3 : 2.00Nd_2O_3$
2.50	$40.00Bi_2O_3 : 20.00BaO : 37.50B_2O_3 : 2.50Nd_2O_3$

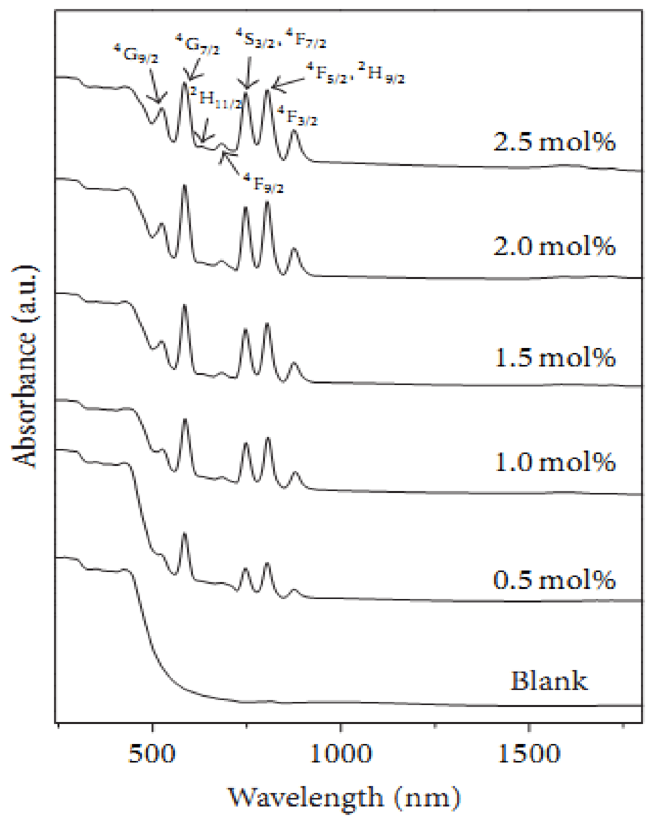

Fig. 20 The optical absorption spectra of Nd^{3+} -doped BiBaBo glass samples

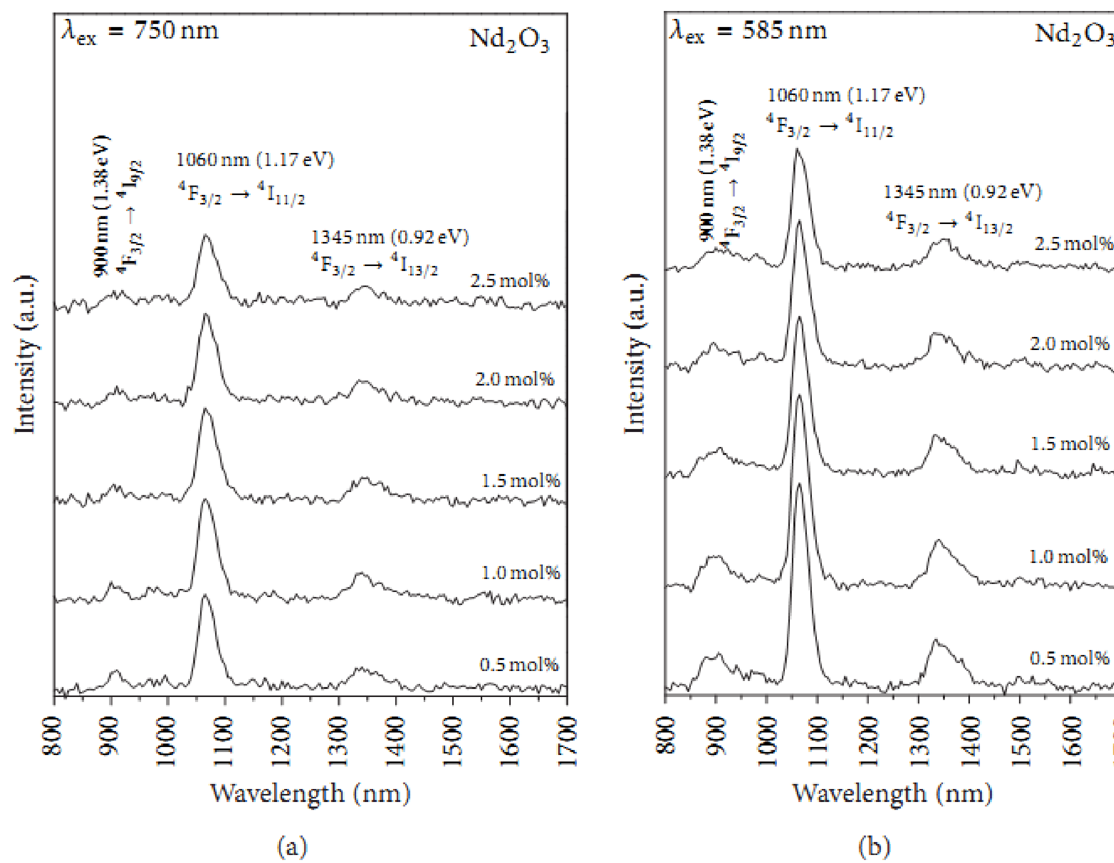

Fig. 21 The NIR emission spectra of Nd^{3+} -doped BiBaBo glass samples when excited by 585 and 750 nm

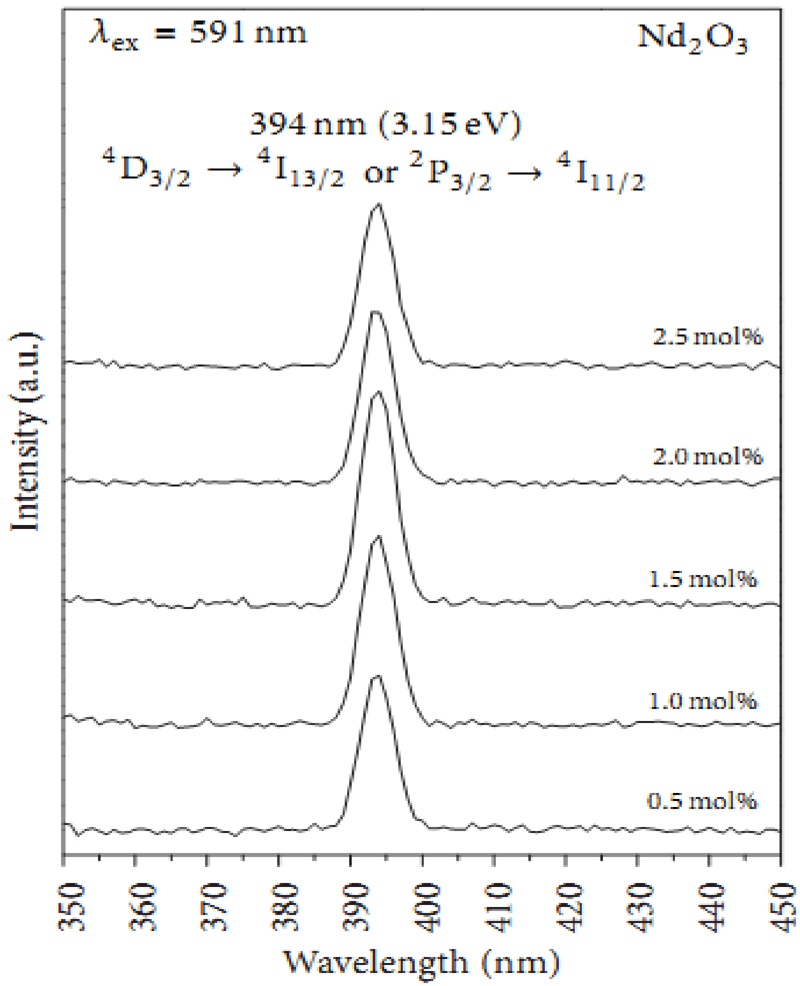

Fig. 22 The upconversion luminescence spectra of Nd^{3+} -doped BiBaBo glass samples when excited by 591 nm

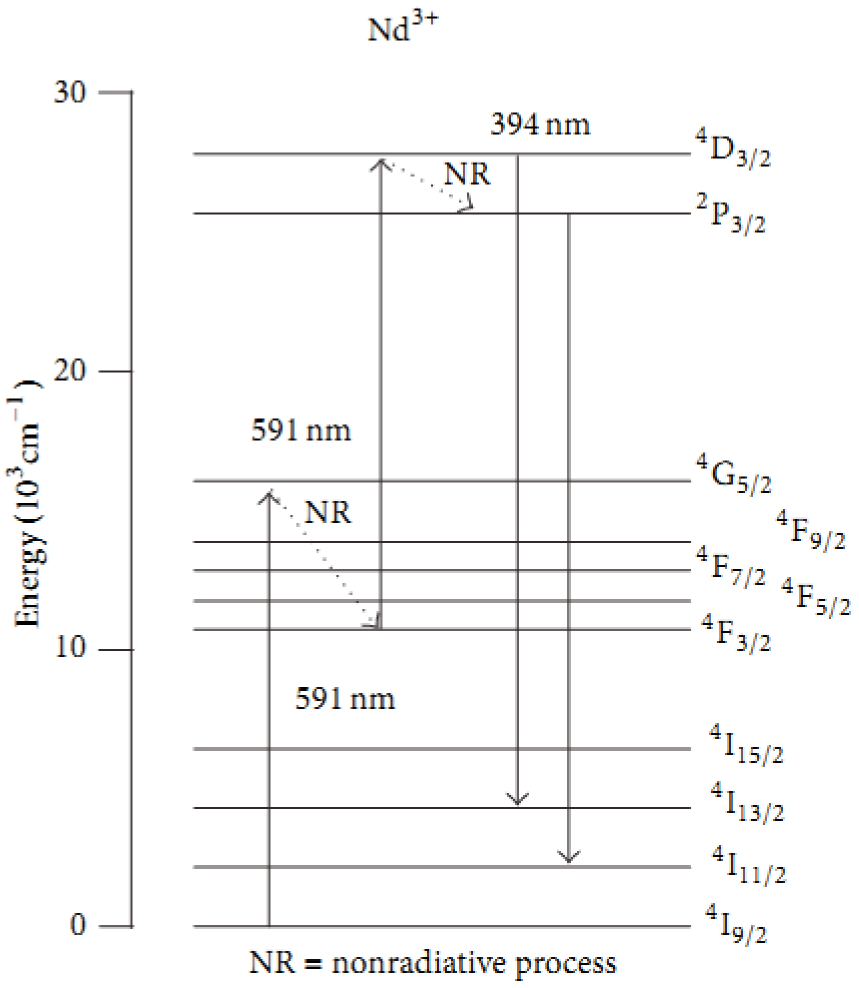

Fig. 23 Energy level of Nd^{3+} -doped BiBaBo glass samples

Next week

Course Outine:

Week 6: - *Transition element in glass*

- *Glass color*
- *Oxidation/Reduction equilibrium in glass*

Case studies from international publications