Supplementary Information

Influence of Gold Nanoparticles on Nonlinear Optical and Photoluminescence Properties of Eu_2O_3 Doped Alkali Borate Glasses

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S1: EDX analysis

To check the chemical composition and quantitative atomic percentage of the compositional elements present in $AuCl_3$ doped glasses, the EDX analyses were done on all the gold containing samples. The EDX spectra of the glass containing 0.01 mol % of $AuCl_3$ (SNBEA-2) is shown in Figure S1. Below table summarizes the detected elements with their relative strength as wt. % and at.%.

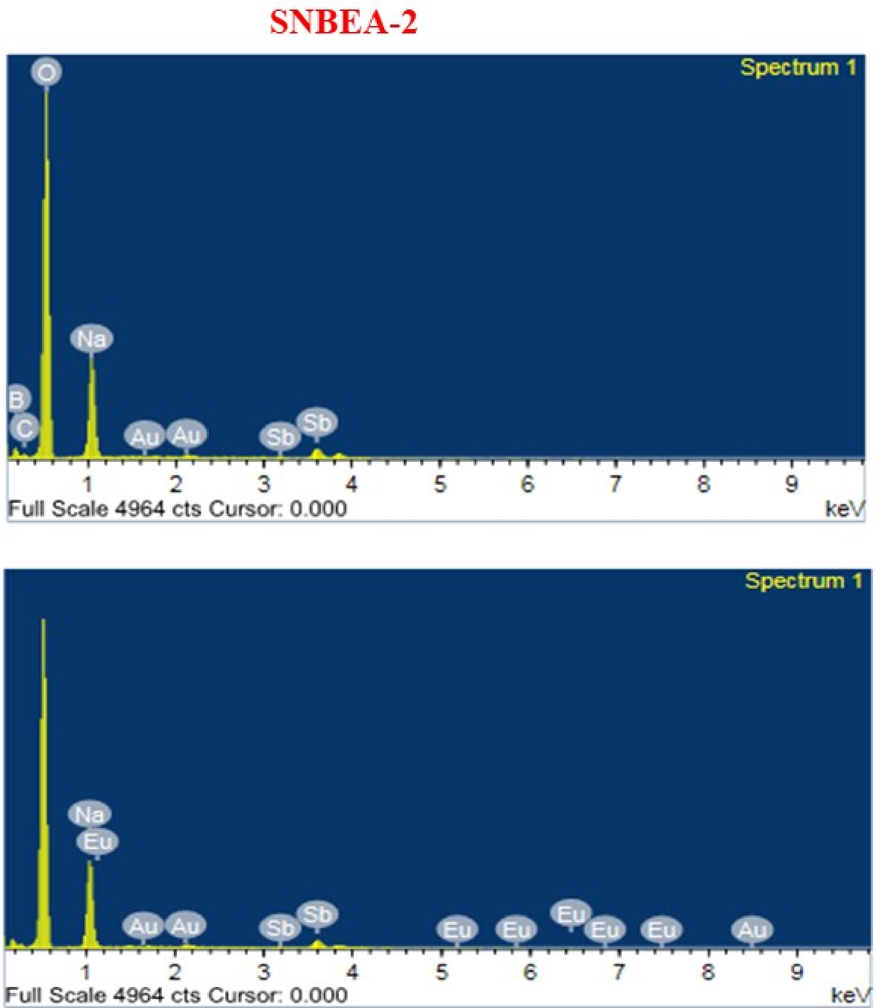

Figure S1: EDX spectra of SNBEA-2 glass sample.

Table S1: The EDX spectra of detected elements in wt % and at % for the studied glasses.

Elements	Line	SNBEA-1		SNBEA-2		SNBEA-3	
		Wt %	At %	Wt %	At %	Wt %	At %
O	K	29.22	62.71	36.98	46.20	36.62	46.85
Na	K	2.78	86.06	3.66	89.33	2.36	83.01
Sb	L	2.17	12.68	1.80	8.32	2.31	15.35
Au	M	0.34	1.22	0.53	1.51	0.25	1.02
Eu	L	0.01	0.05	0.23	0.85	0.12	0.62
B	-	-	-	14.03	25.95	14.15	26.78
C		10.97	31.36	13.88	23.10	13.75	23.43

S2: Optical Dielectric Constant

In amorphous materials the absorption due to the band to band transitions can be utilized for determining the optical band gap via the Tauc relation[S1] $\alpha(\nu) = (B/h\nu)(h\nu - E_g)^n$, where B is a constant and hν the photon energy, E_g is the energy band gap and n is an index which can have values 2, 3, 1/2, and 1/3 depending on the nature of the interband electronic transitions.[S2] The goodness of the fitting of the data has been determined by considering either n =1/2 (direct band gap) or n = 2 (indirect band gap) in the above mentioned equation. For amorphous materials, indirect transitions are valid according to Tauc relation because the absorption edge has a finite slope in amorphous materials. Thus, when analysing the variation in optical absorption with respect to the photon energy, n = 2 is valid. By extrapolation of the linear region of a plot of $(\alpha h\nu)^{1/n}$ versus photon energy (hν) gives the value of the energy band gap (E_g) when $(\alpha h\nu)^{1/n} = 0$ as shown in below Figure S2 (a). Figure S2 (b) represent the variation of E_g values with respect to $AuCl_3$ concentration. Also, the refractive index is related to energy band gap,[S3] hence the refractive index values are calculated from energy band gap values along with dielectric constant ($\epsilon=n^2$) and are furnished in Table S2.

From the Table S2 it is evident that, the band gap energy values are decreased with increase in the gold concentration in glass matrix. The decrease trend of E_g values is assigned to the structural changes occurring with addition of Au into glass matrix. The other possibility for the reduction in band gap is due to the formation of greater number of non-bridging oxygens (NBOs) and the shift of the valence band edge to higher energies.[S4] Since the NBOs are more polarizable than bridging oxygens (BOs) hence the refractive index values of the samples are increased as a function of $AuCl_3$ concentration. It is found that, the refractive index values evaluated from the band gap energies are higher compared to those measured experimentally which might be due to the fact that, it is well known that the refractive index increases with decrease in the wavelength. In other words the refractive index increases as the excitation energy approaches the bandgap energy. The refractive index values are experimentally measured using Abbe's refractometer using sodium vapour lamp as a light source that emits light of wavelength of 589.3 nm. The energy component of excitation light is lesser compared to energy band gap value. Hence the experimental refractive index values are lesser compared to those evaluated from the band gap energy. Further, from the Table S2 it is also evident that the dielectric constant is increased with respect to $AuCl_3$ concentration owing to the higher polarizability of the glass system occurred due to the creation of NBOs.[S5]

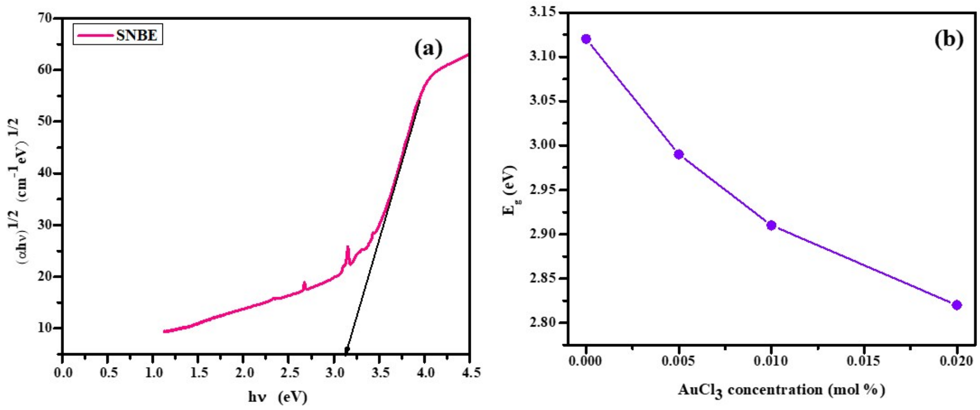

Figure S2: **(a)** Typical plot of $(\alpha h\nu)^{1/2}$ versus (hν) in SNBE (gold free) glass, **(b)** variation of E_g as a function of $AuCl_3$ concentration.

Table S2: Variation of band gap energy, the refractive index and dielectric constant as a function of $AuCl_3$ concentration.

$AuCl_3$ concentration (mol %)	energy band gap, E_g (eV)	Refractive index (n)	Dielectric constant ($\epsilon=n^2$)
0	3.12	2.36	5.56
0.005	2.99	2.39	5.71
0.01	2.91	2.41	5.81
0.02	2.82	2.44	5.95

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