# Supplementary Information

# Highly efficient near-infrared solid solution phosphors with excellent thermal stability and tunable spectra for pc-LED light source toward NIR spectroscopy applications

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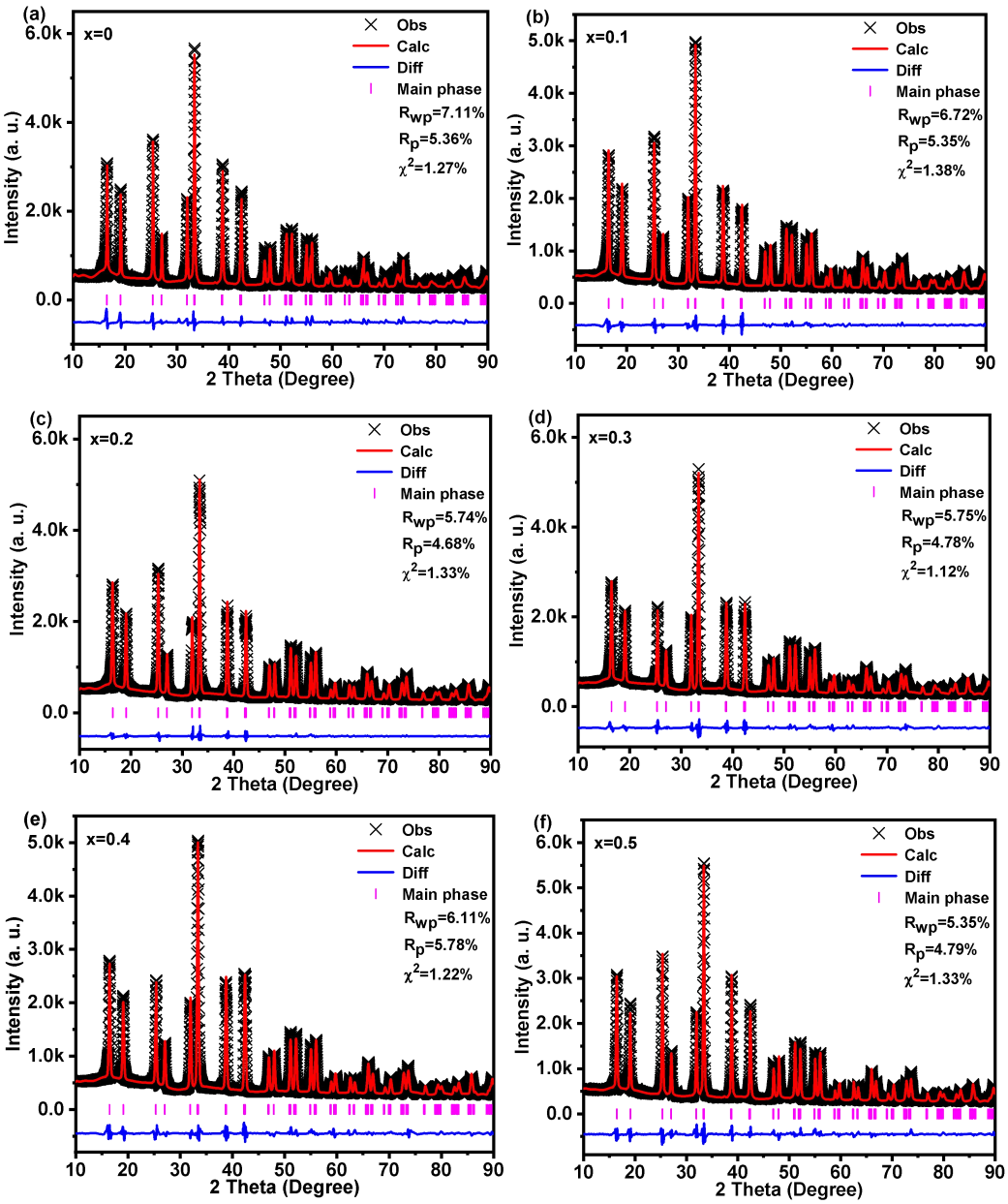


Fig.S1 Rietveld refinement of GLASB:$Cr^{3+}$ (x=0, 0.1, 0.2, 0.3, 0.4 and 0.5).

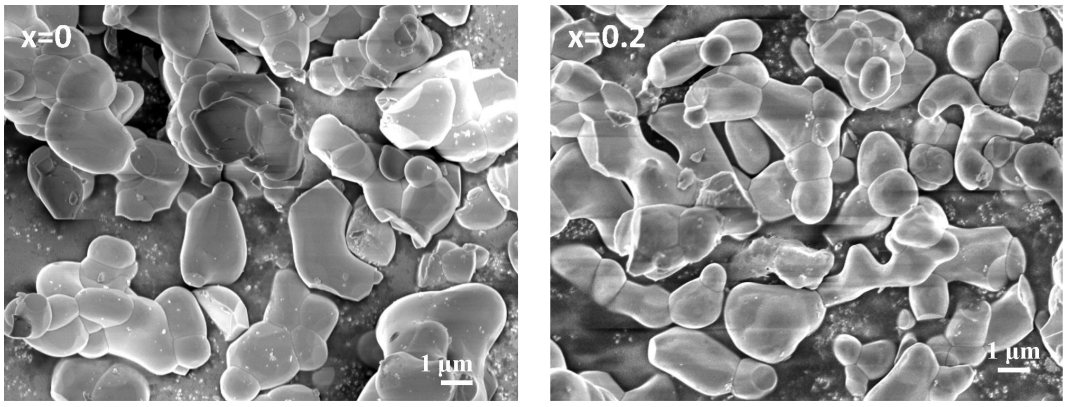


Fig. S2 SEM images of GLASB:$Cr^{3+}$ (left, x = 0; and right, x = 0.2) with ×5 kx magnifications.

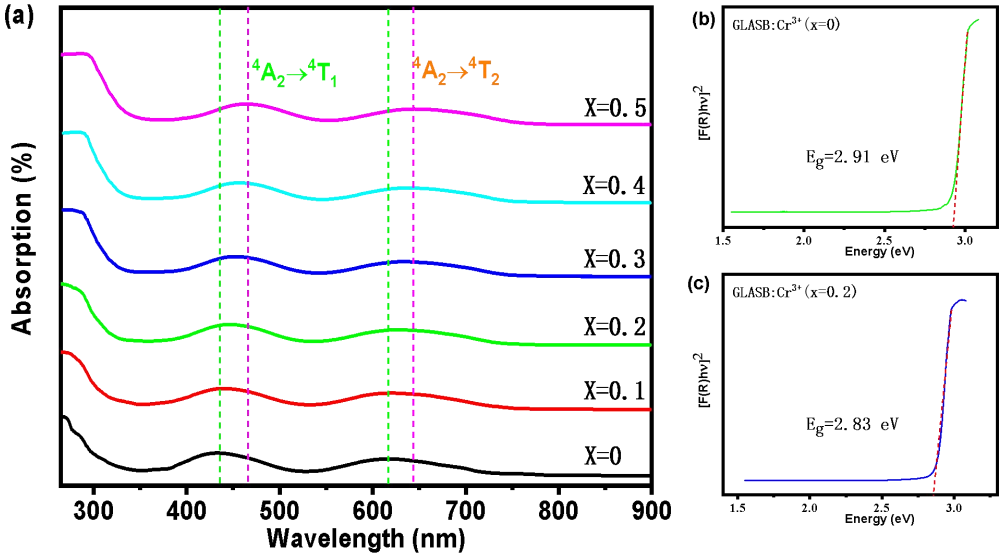


Fig. S3 (a) UV-vis-NIR absorption spectra of GLASB:$Cr^{3+}$ (x=0-0.5). (b, c) The fitting of the corresponding band gap energies of GLASB:$Cr^{3+}$ (x=0 and 0.2) phosphors.

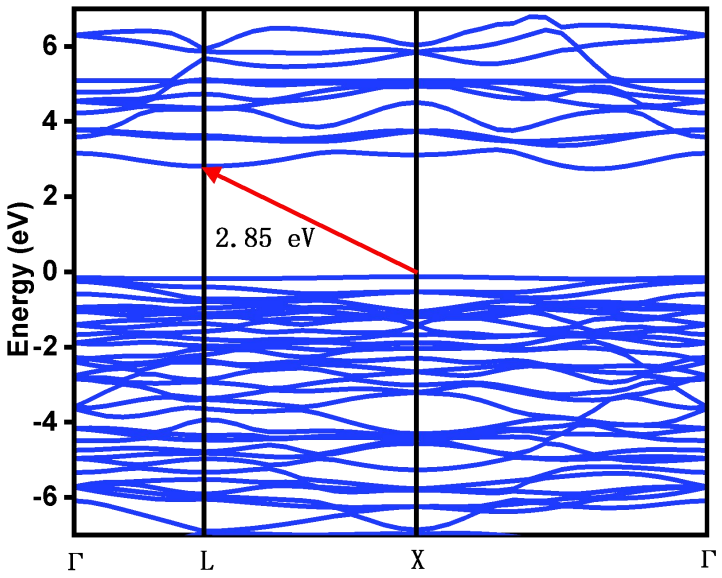


Fig. S4 Calculated electronic band structure

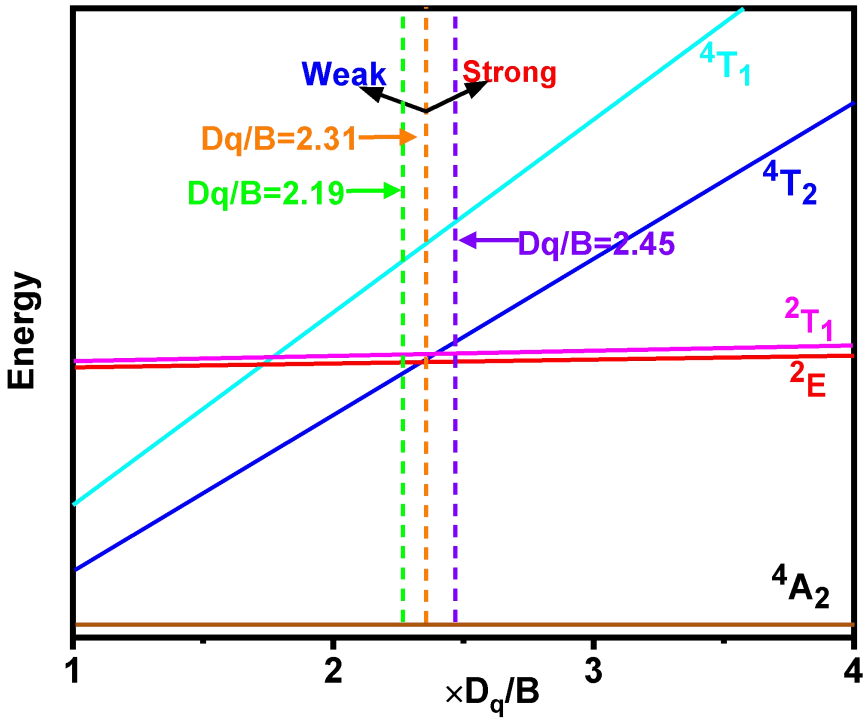


Fig. S5 Tanabe-Sugano ($3d^3$) diagram.

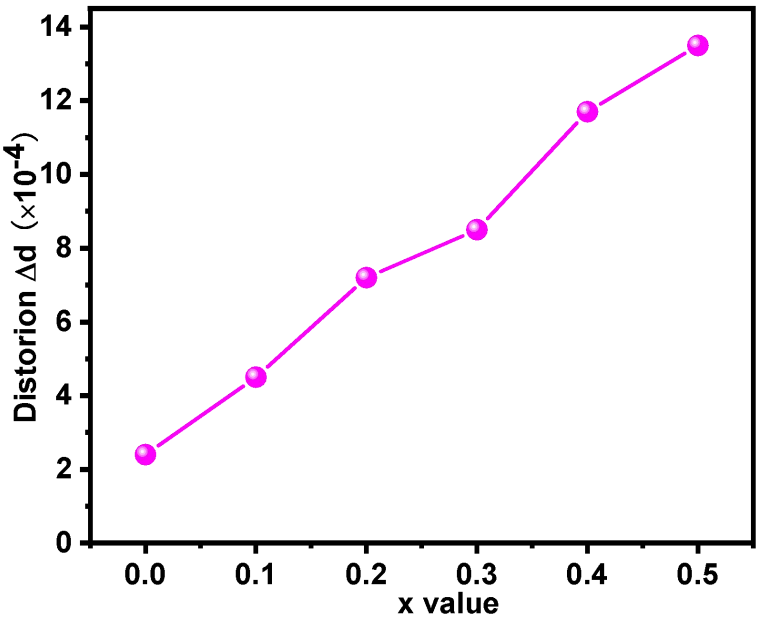


Fig. S6 The linear relationship between the octahedral distortion (Δd) and dissolved x content

**Table S1.** Refined Crystallographic Parameters for GLASB:$Cr^{3+}$.

| Parameters | x=0 | x=0.1 | x=0.2 | x=0.3 | x=0.4 | x=0.5 |
|---|---|---|---|---|---|---|
| Space group | Hexagonal | | | | | |
| α/β/γ | 90°/90°/120 | | | | | |
| a/b/c (Å) | 7.229/ 9.313/ 16.187 | 7.232/ 9.324/ 16.209 | 7.249/ 9.328/ 16.222 | 7.267/ 9.351/ 16.243 | 7.315/ 9.386/ 16.302 | 7.332/ 9.392/ 16.336 |
| Cell volume ($Å^3$) | 1089 | 1091.1 | 1091.8 | 1093.9 | 1095.3 | 1095.9 |
| $R_{wp}$ | 7.11% | 6.72% | 5.74% | 5.75% | 6.11% | 5.35% |
| $R_p$ | 5.36% | 5.35% | 4.68% | 4.78% | 5.78% | 4.79% |
| $\chi^2$ | 1.27% | 1.38% | 1.33% | 1.12% | 1.22% | 1.33% |

**Table S2.** Selected (Al, Sc, Cr)-O bond lengths (Å) of GLASB:$Cr^{3+}$.

| bond lengths | X=0 | X=0.2 |
|---|---|---|
| (Al, Sc, Cr)-O1 | 1.8672 (5) | 1.8678(2) |
| (Al, Sc, Cr)-O2 | 1.9012 (4) | 1.9115(3) |
| (Al, Sc, Cr)-O3 | 1.9081 (1) | 1.9085(1) |
| (Al, Sc, Cr)-O4 | 1.9080 (4) | 1.9083(3) |
| (Al, Sc, Cr)-O5 | 1.9009 (2) | 1.9112(4) |
| (Al, Sc, Cr)-O6 | 1.8688 (3) | 1.8791(5) |
| Average | 1.8923 | 1.8978 |

**Table S3.** Performance parameters for GLASB:$Cr^{3+}$ (x=0-0.5).

| Compound | Peak | FWHM | $\Delta d$ ($\times 10^{-4}$) | $\lambda_{oct}$ | $\sigma^2_{oct}$ |
|---|---|---|---|---|---|
| x=0.0 | 747 | 128 | 2.31 | 1.0235 | 5.08 |
| x=0.1 | 789 | 167 | 4.38 | 1.0265 | 5.17 |
| x=0.2 | 806 | 196 | 7.08 | 1.0338 | 5.39 |
| x=0.3 | 843 | 182 | 8.22 | 1.0440 | 5.51 |
| x=0.4 | 858 | 179 | 11.57 | 1.0537 | 5.60 |
| x=0.5 | 866 | 177 | 13.15 | 1.0654 | 5.76 |

**Table S4**. Luminescent parameters of $Cr^{3+}$ in different host materials and photoelectric properties of the fabricated NIR pc-LED

| **Phosphor** | **$\lambda_{max}$ (nm)** | **FWHM (nm)** | **IQE (%)** | **TQ at 150 ℃ (%)** | **NIR output power/efficiency of pc-LED** | **Ref.** |
|---|---|---|---|---|---|---|
| GLASB:$Cr^{3+}$ | 806 | 196 | 93.6 | 105.7 | 46 mW/37% @100 mA | **This work** |
| $Ca_3Sc_2Si_3O_{12}$:$Cr^{3+}$ | 740 | 140 | 91 | 100 | 650-1000 | [1] |
| $Ca_2LuHf_2Al_3O_{12}$:$Cr^{3+}$ | 785 | 145 | - | - | 3.1 mW/14% @120 mA | [2] |
| $Ca_3Ga_2Ge_3O_{12}$:$Cr^{3+}$ | 803 | 267 | - | 90% | 27.1 mW/16.3% @100 mA | [3] |
| $ScBO_3$:$Cr^{3+}$ | 800 | 120 | 65 | 51 | 26 mW/7% @120 mA | [4] |
| $La_3Ga_5GeO_{14}$:$Cr^{3+}$ | 750 | 330 | - | - | 18.2 mW/- @350 mA | [5] |
| $Ca_2LuZr_2Al_3O_{12}$:$Cr^{3+}$ | 752 | 117 | 69 | 60 | 2.44 mW/4.1% @120 mA | [6] |
| $NaInP_2O_7$:$Cr^{3+}$ | 856 | 133 | 71.3 | 47 | 39.1 mW/10.9% @120 mA | [7] |
| $NaScSi_2O_6$:$Cr^{3+}$ | 840 | 140 | - | | | [8] |
| $LiScP_2O_7$:$Cr^{3+}$ | 880 | 170 | 38 | | 19 mW@100 mA | [9] |
| $InBO_3$:$Cr^{3+}$ | 820 | 138 | 46 | | 37.50 mW@120 mA | [10] |
| $LiInP_2O_7$:$Cr^{3+}$ | 860 | 165 | 20 | | 6.42 mW@100 mA | [11] |
| $NaScGe_2O_6$:$Cr^{3+}$ | 895 | 162 | 40.2 | | 12.07 mW@350 mA | [12] |
| $LiGaP_2O_7$:$Cr^{3+}$ | 846 | 170 | 48 | | 28.10 mW@120 mA | [13] |

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