Electronic Supporting Information

Near-Infrared-Laser-Driven Robust Glass-Ceramic-Based Upconverted Solid-State-Lighting

Jiangkun Chen,[a,c,d] Yongzhao Peng,[b] Xinyue Li,[b] Wu Chen,[a,c,d] Hai Huang,[a,c,d] Lin Lin,[a,c,d]

Daqin Chen*[,a,b,c]

[a]College of Physics and Energy, Fujian Normal University, Fujian Provincial Key Laboratory of Quantum Manipulation and New Energy Materials, Fuzhou, Fujian 350117, China

[b]College of Materials & Environmental Engineering, Hangzhou Dianzi University, Hangzhou, Zhejiang 310018, China

[c]Fujian Provincial Collaborative Innovation Center for Optoelectronic Semiconductors and Efficient Devices, Xiamen, Fujian, 361005, China

[d]Fujian Provincial Engineering Technology Research Center of Solar Energy Conversion and Energy Storage, Fuzhou, Fujian, 350117, China

*Corresponding author, E-Mail: dqchen@fjnu.edu.cn (D. Q. Chen)

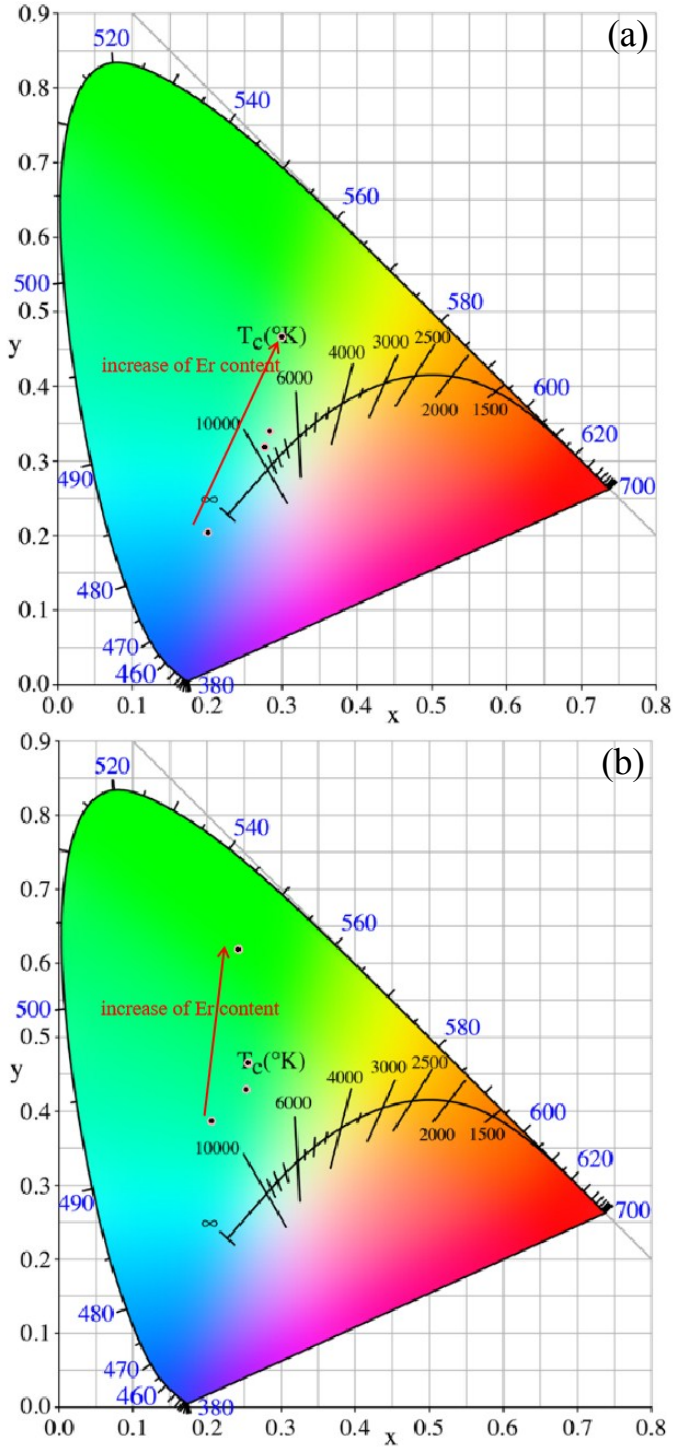

Figure S1 Dependence of CIE color coordinates for a series of Yb/Tm/Er (20/0.25/x, mol%) doped GCs with different Er^{3+} contents: (a) α-$NaYF_4$ GC (x=0.25, 0.35, 0.45, 0.50), (b) β-$NaYF_4$ GC (x=0.06, 0.09, 0.12, 0.25).

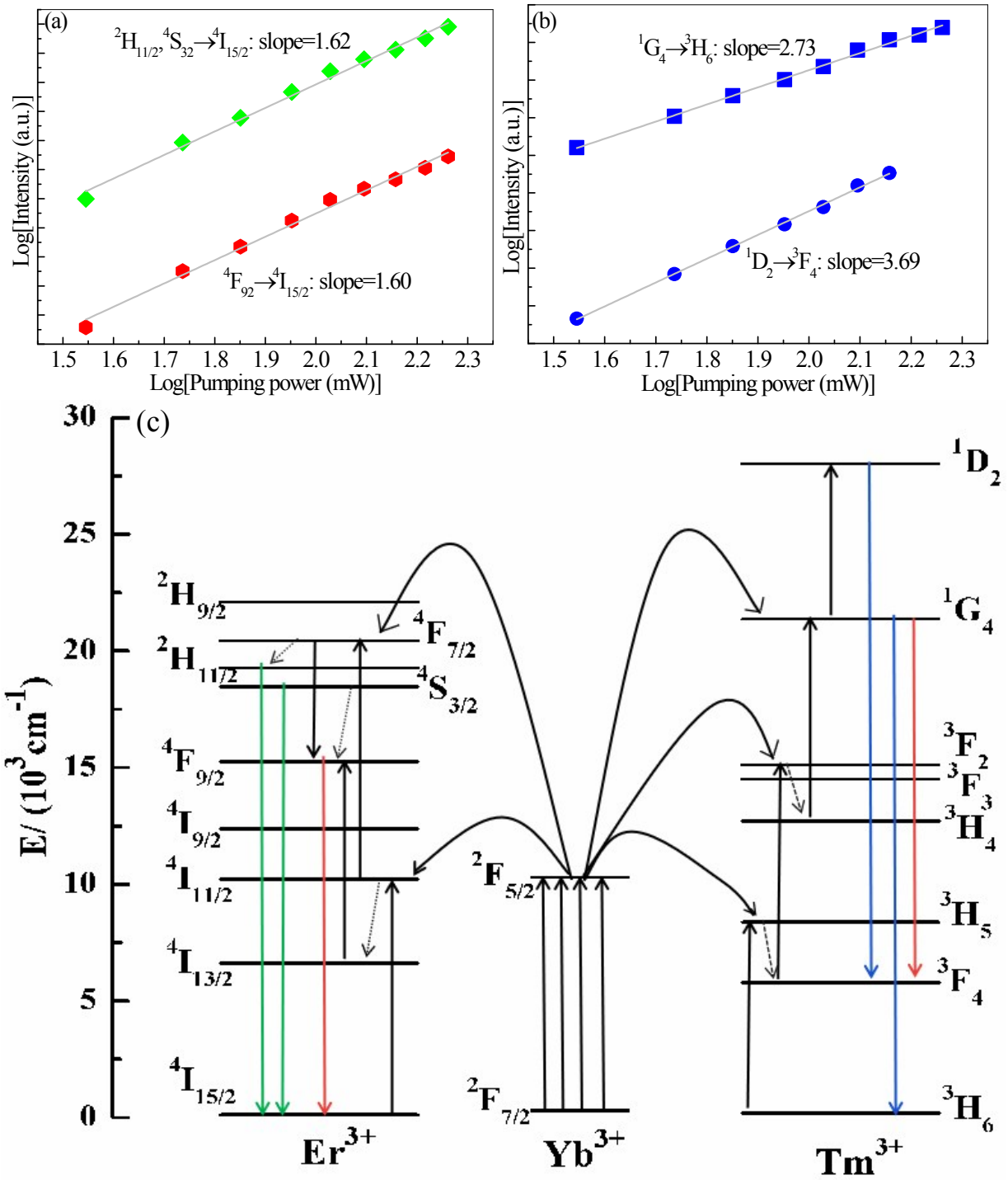

Figure S2 Log-log plots of UC intensity versus NIR excitation power for the investigated GC samples: (a) Yb/Er doped GC and (b) Yb/Tm doped GC. (c) Schematic illustration of energy transfer processes to achieve blue, green and red UC emissions in Yb/Tm/Er doped GCs.

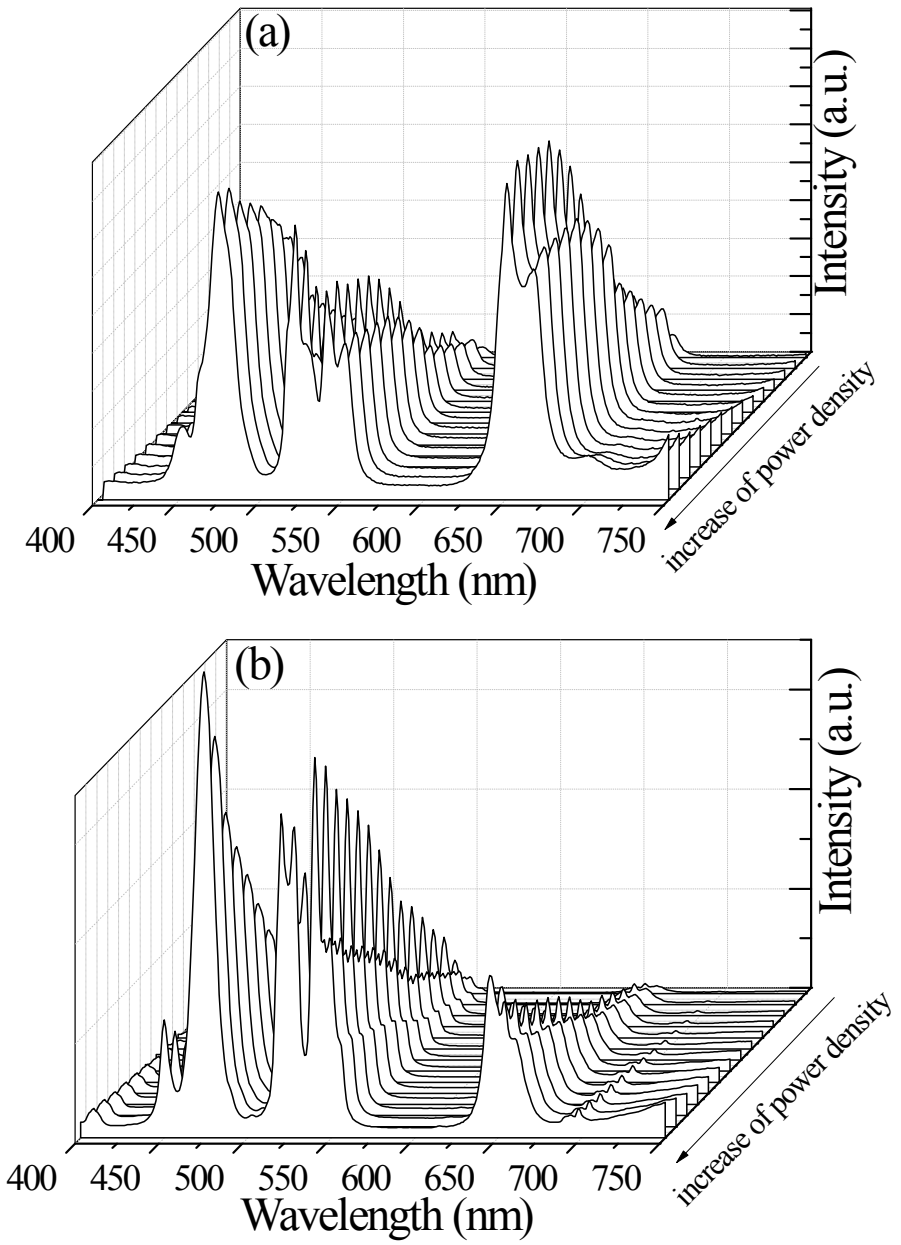

Figure S3 Laser power density dependent UC emission spectra for (a) Yb/Tm/Er (20/0.25/0.45 mol%) doped α-$NaYF_4$ GC and (b) Yb/Tm/Er (20/0.25/0.12 mol%) doped β-$NaYF_4$ GC.

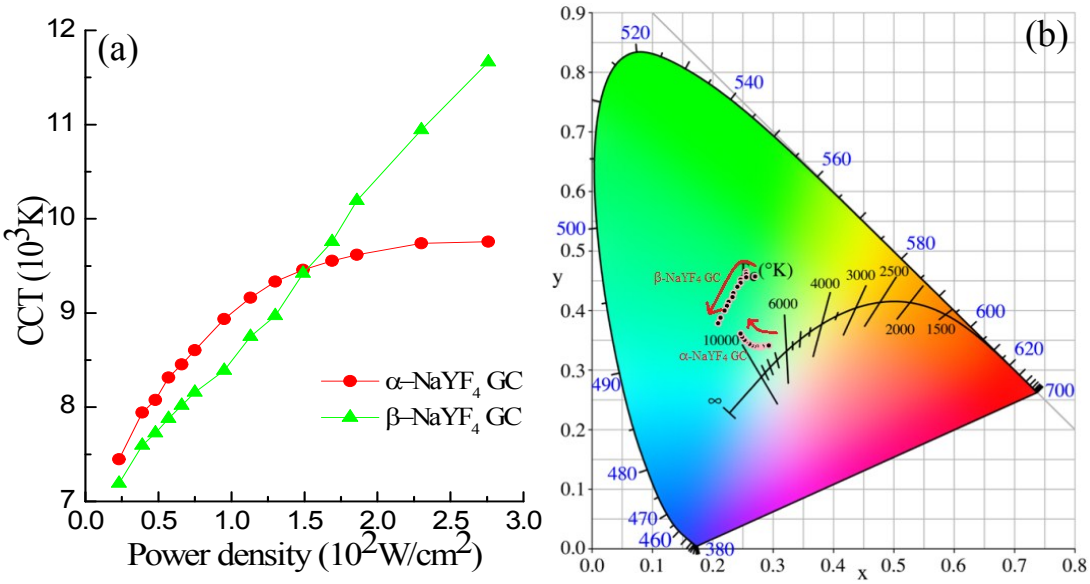

Figure S4 Variation of (a) CCT and (b) CIE color coordinates for the GC-based (Yb/Tm/Er doped α-$NaYF_4$GC or β-$NaYF_4$GC) UC lighting with increase of incident laser powder density.

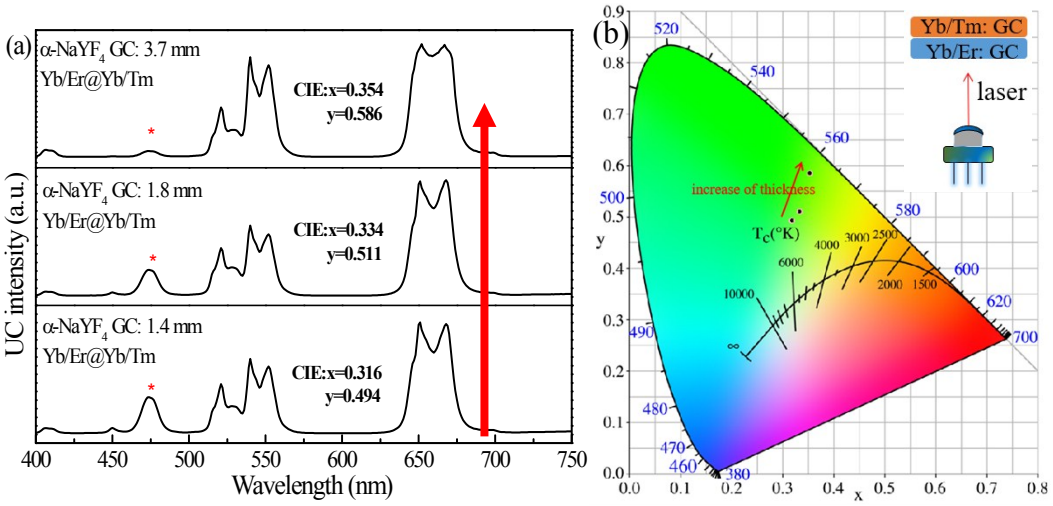

Figure S5 Variation of (a) UC emission spectra and (b) CIE color coordinates for the GC-based UC lighting with increase of α-$NaYF_4$ GC thickness. The Yb/Er doped α-$NaYF_4$ GC @ Yb/Tm doped β-$NaYF_4$ GC stacking structure (denoted as Yb/Er@Yb/Tm) is used as color converter.

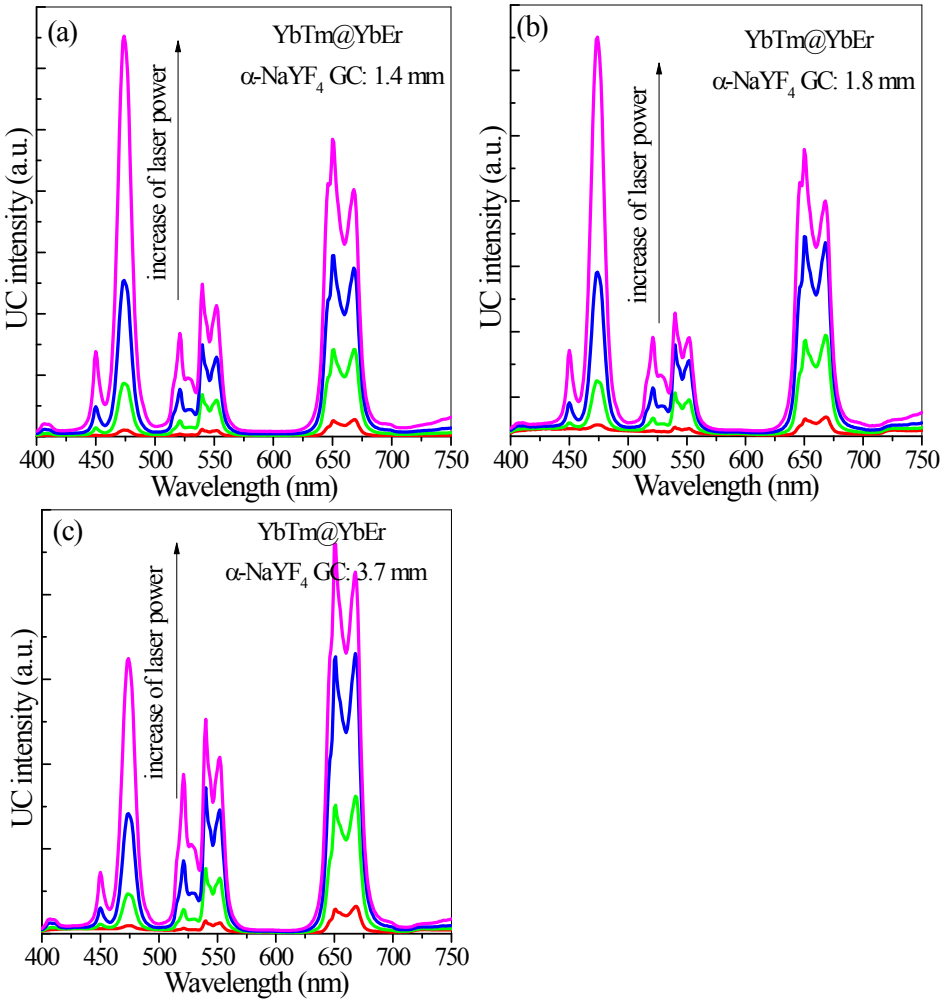

Figure S6 Laser powder dependent UC emission spectra for the constructed GC-based UC lighting with increase of α-$NaYF_4$ GC thickness: (a) 1.4 mm, (b) 1.8 mm and (c) 3.7 mm. The Yb/Tm doped β-$NaYF_4$ GC @ Yb/Er doped α-$NaYF_4$ GC stacking structure (denoted as Yb/Tm@Yb/Er) is used as color converter.

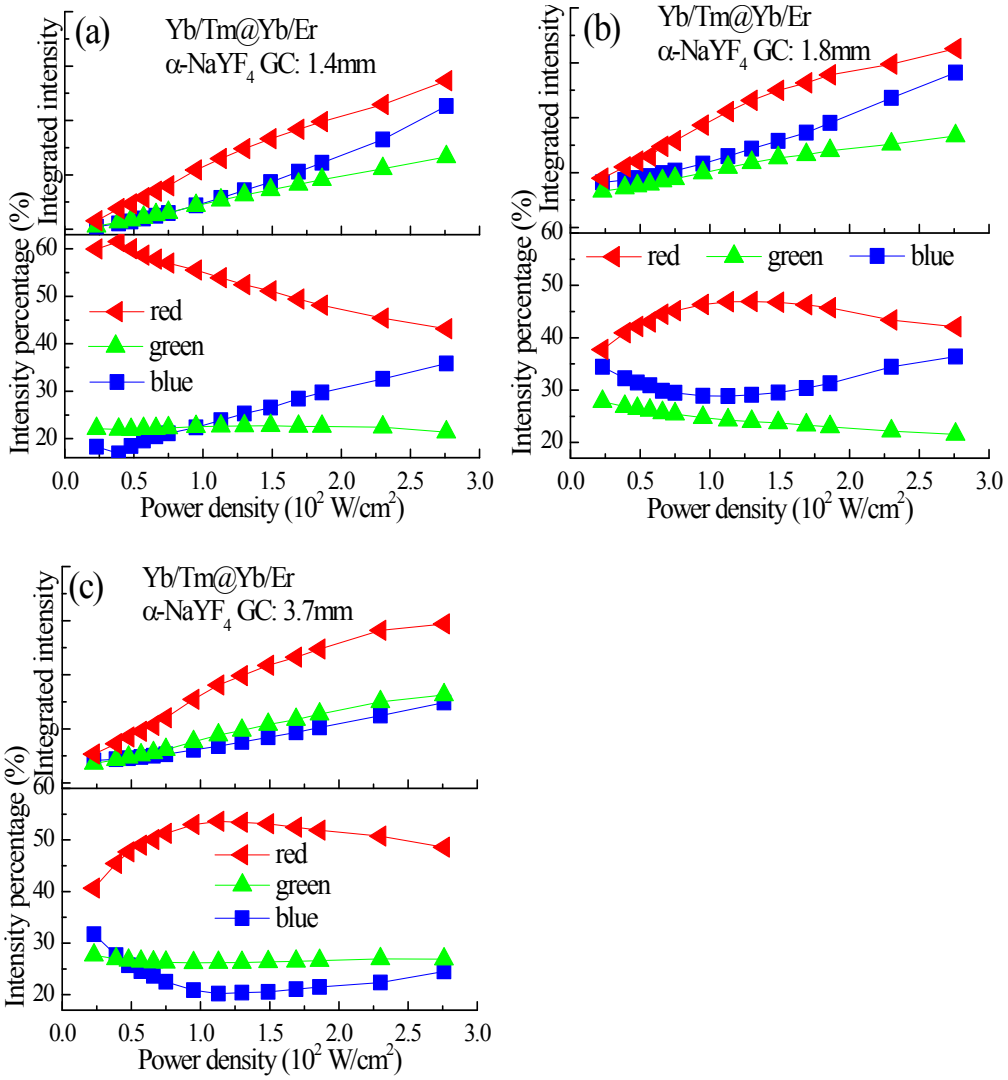

Figure S7 Dependence of red/green/blue emission intensities and the corresponding intensity percentage for the constructed GC-based UC lighting with increase of α-$NaYF_4$ GC thickness: (a) 1.4 mm, (b) 1.8 mm and (c) 3.7 mm. The Yb/Tm doped β-$NaYF_4$ GC @ Yb/Er doped α-$NaYF_4$ GC stacking structure (denoted as Yb/Tm@Yb/Er) is used as color converter.

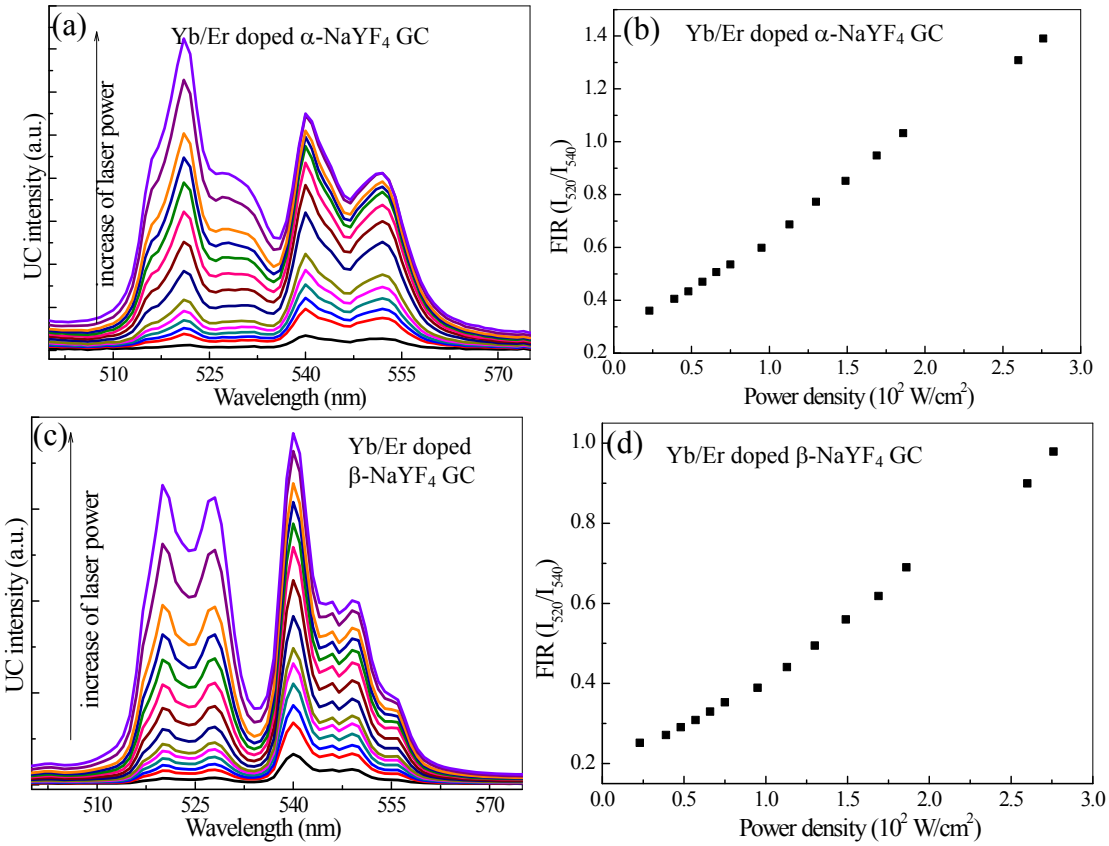

Figure S8 Laser power dependent UC emission spectra for the (a) Yb/Er doped α-$NaYF_4$ GC and (c) β-$NaYF_4$ GC samples. (b, d) The calculated FIR value between $^2H_{11/2}\rightarrow{}^4I_{15/2}$ transition (I_{520}) and $^4S_{3/2}\rightarrow{}^4I_{15/2}$ one (I_{540}) versus laser power density.

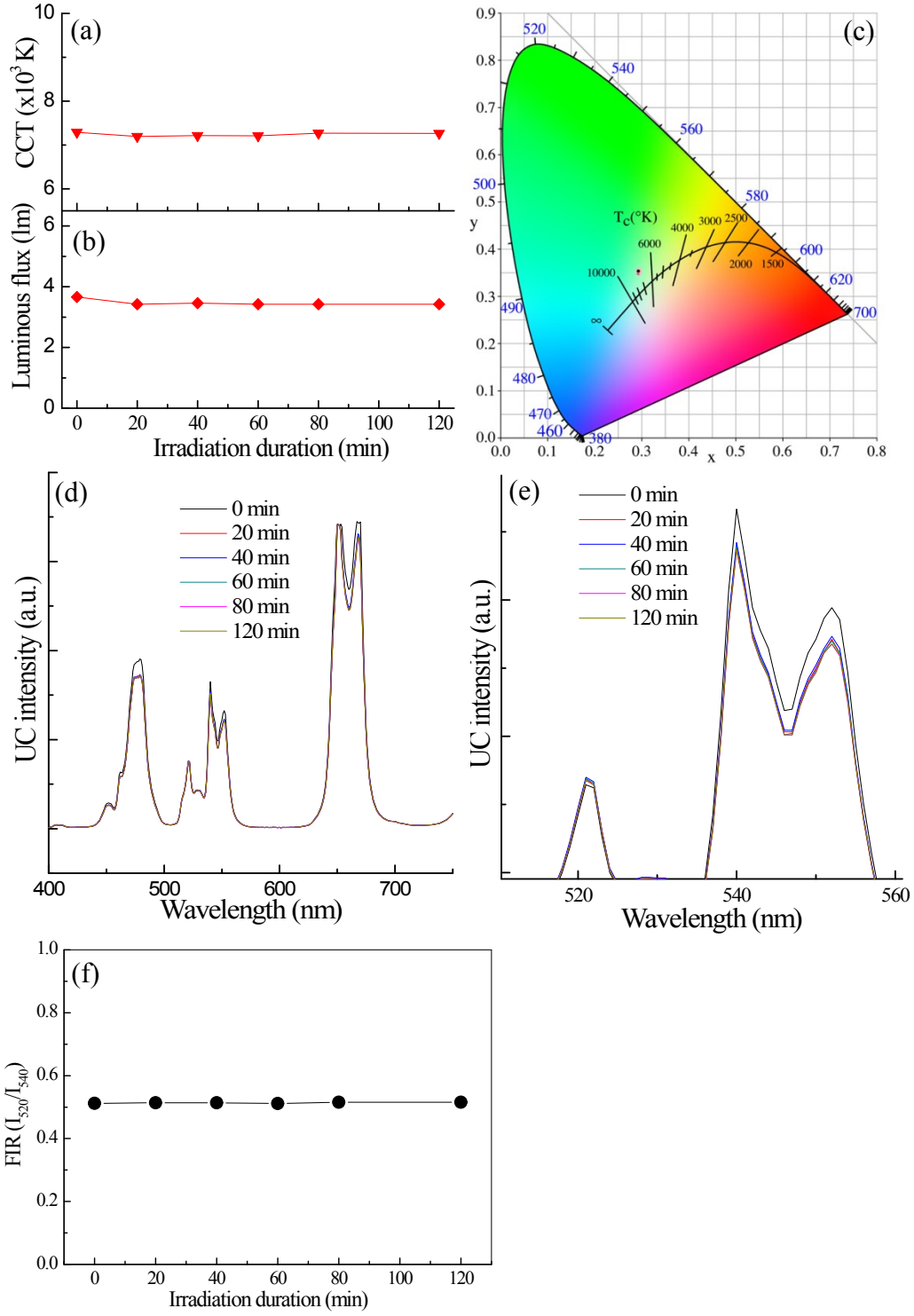

Figure S9 Laser (230 W/cm^2) irradiation duration dependent (a) CCT, (b) luminous flux, (c) CIE color coordinates, (d, e) UC emission spectra and (f) FIR value for the constructed GC-based UC lighting. The Yb/Tm doped β-$NaYF_4$ GC @ Yb/Er doped α-$NaYF_4$ GC stacking structure (denoted as Yb/Tm@Yb/Er) is used as color converter.