

Dynamic irradiation-responsive materials for advanced anti-counterfeiting in dark and bright fields

Wenbo Dong [†], Wenxiang Wang [†], Mingyu Wang, Jiachi Zhang ^{*} and Yuhua Wang ^{*}

National & Local Joint Engineering Laboratory for Optical Conversion Materials and Technology, Lanzhou University, Lanzhou 730000, P. R. China

[†]These authors contributed equally to this work.

^{*}Authors to whom correspondence should be addressed:

Dr. Jiachi Zhang, Email: zhangjch@lzu.edu.cn

Dr. Yuhua Wang, Email: wyh@lzu.edu.cn

Tel.: +86-931-8912772, Fax: +86-931-8913554

Table S1. Crystallographic data of CaZnGe₂O₆

Formula	CaZnGe ₂ O ₆
Crystal system	Monoclinic
Space group	C 1 2/c 1
Lattice parameters	
a(Å)	10.16020
b(Å)	9.00979
c(Å)	5.43341
$\alpha^\circ=\gamma^\circ$	90
β°	105
Cell volume (Å ³)	480.483
T/K	296
Diffractometer	Rigaku D/Max-2400
Radiation/Å	Cu-Ka ($\lambda=1.5405$)
Absorption correction	multi-scan
2 θ range $^\circ$ /	5-140
Z	4
Calculated Density	4.7986g/cm ³
R-factors	
Rwp	11.48%
χ^2	1.88
RExp	6.11%

Table S2. Three cation sites Ion radius and electronegativity of Ca²⁺, Zn²⁺, and Ge⁴⁺ ions in CaZnGe₂O₆.

Vector	Ion radius (Å)	Electronegativity
Ca (8)	1.12	1.160
Zn (6)	0.74	1.336
Ge (4)	0.39	1.854

Table S3. Ion radius and electronegativity of Ca^{2+} , Zn^{2+} , Pb^{2+} and Ge^{4+} ions in $\text{CaZnGe}_2\text{O}_6$ based on the Hume-Rothery rules.

Vector	Ion radius (\AA)	Δr (\AA)	Error (%)	Electronegativity	Error (%)
Ca (8)	1.120	0.170	13.2	1.160	5.3
Ge (4)	0.390	0.900	69.8	1.854	51.3
Zn (6)	0.740	0.550	42.6	1.336	9.1
Pb (8)	1.290	--	--	1.225	--

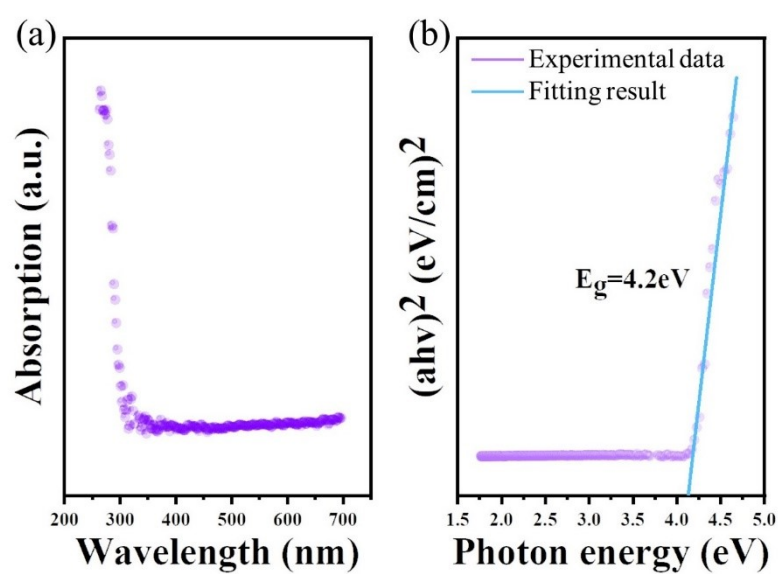


Figure S1. Absorption spectrum of $\text{CaZnGe}_2\text{O}_6$ and the fitting result of band gap.

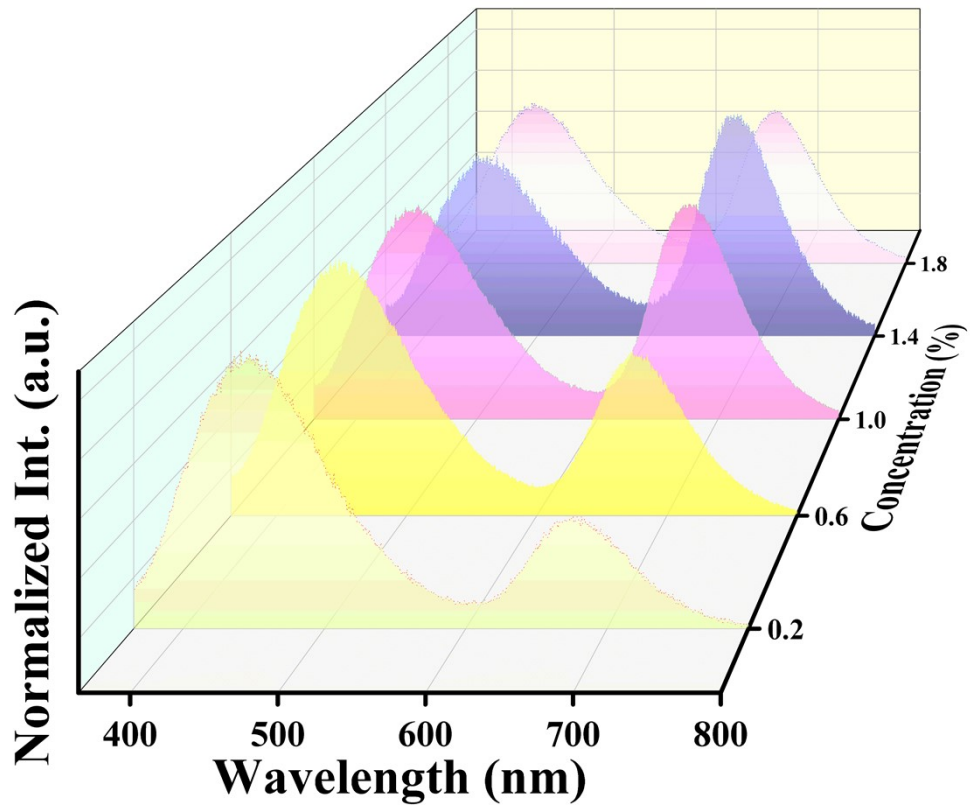


Figure S2. PL of the CZGO: $x\%Pb^{2+}$ materials ($x=0.2\%,0.6\%,1.0\%,1.4\%,1.8\%$)

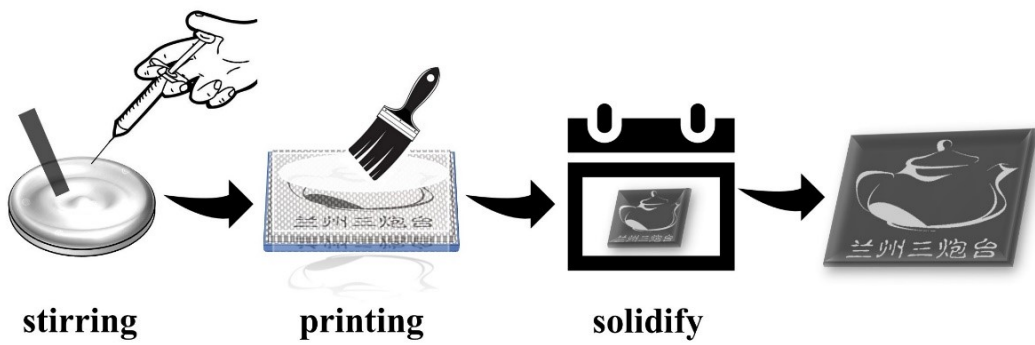


Figure S3. Fabrication process of the luminescent anti-counterfeiting image.

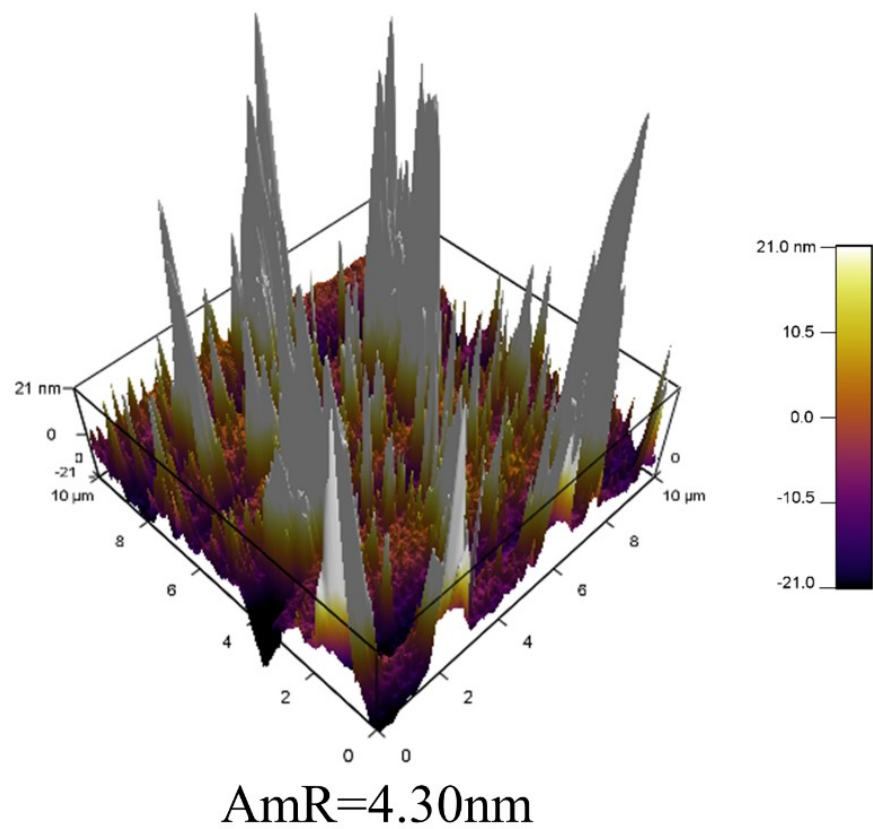


Figure S4. The 3D roughness of compounds measured by MFP-3D.