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Supplementary Information

Dual-wavelength enhanced upconversion luminescence properties of Li^+ doped $NaYF_4$:Er,Yb glass-ceramic for all-optical logic operations

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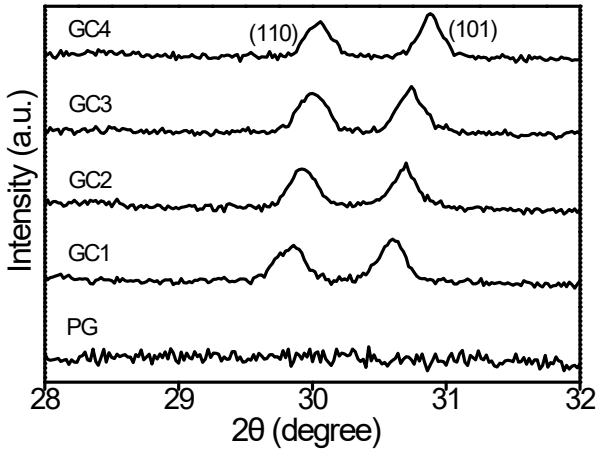

Fig. S1. The magnified XRD diffraction peaks assigned to (110) and (101) planes.

Fig. S1 is the magnified XRD diffraction peaks assigned to (110) and (101) planes. With the increase of Li^+ doping concentration (GC1 to GC4), the peak position gradually shifted towards larger angles. It is well known that the ionic radius of Li^+ ion is much smaller than that of Na^+ and Y^{3+}, where Li^+ ions can be easily accommodated in the lattice. According to Bragg's law: $2d\sin\theta = n\lambda$, where d represents the interplanar spacing, θ is the Bragg diffraction angle, n is the diffraction order, and λ indicates the diffraction wavelength of X-ray. When n and λ are fixed, the θ inversely proportional to d. When doping the Li^+ ions, Na^+ ions at the lattice position are preferentially replaced by Li^+, as a result, the lattice shrinks and d decreases, which leads to θ offset to a higher angle. In other words, the lattice spacing decreasing indicates that the Li^+ ion with small radius enters the lattice and replaces the Na^+ ion with large radius.

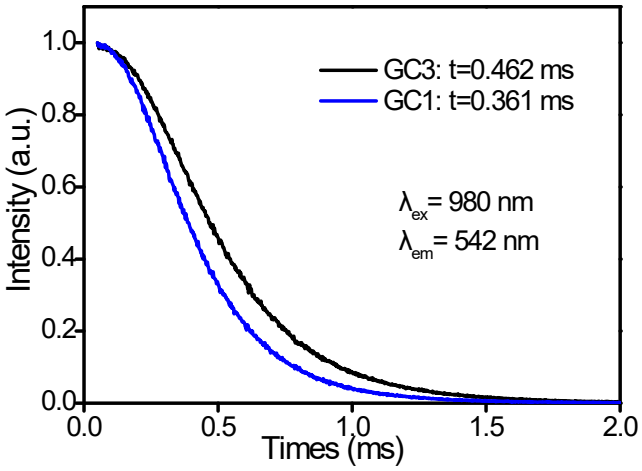

Fig. S2. Luminescence decay curves for GC1 and GC3 samples at 542 nm UC emissions under the excitation of 980 nm laser.

The fluorescence decay curves of GC1 and GC3 samples are in good agreement with the single exponential decay indicated by formula $I(t)=I_0 + Aexp\ (-t/\tau)$, where t is the time, $I(t)$ and I_0 are the upconversion (UC) intensities at time t and 0, respectively, A is a constant, t is the time, and τ is the decay time for the exponential components. And the quite similar fitting equations of both of GC1 and GC3 samples at 542 nm and 656 nm indicate that Li^+ doping does not make a fundamental change to the UC mechanism of GC samples. Under 980 nm laser excitation, the fluorescence lifetime of GC1 sample at 542 nm emission is 0.361 ms, while GC3 sample is 0.462 ms. The result further shows that Li^+ ions doping could enhance the UC luminescence intensity of GC samples, which is consistent with UC spectral results.

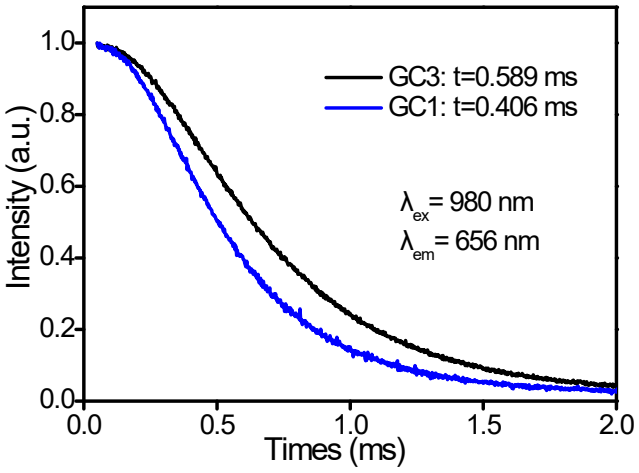

Fig. S3. Luminescence decay curves for GC1 and GC3 samples at 656 nm UC emissions under the excitation of 980 nm laser.

The fluorescence decay curves of GC1 and GC3 samples at 656 nm emission are also in good agreement with the single exponential decay indicated by formula $I(t)=I_0 + Aexp\ (-t/\tau)$. The fluorescence lifetime of GC1 sample at 656 nm emission is 0.406 ms, while GC3 sample is 0.589 ms, which also indicates that Li^+ ions doping could enhance the UC luminescence intensity of GC samples.