Promising lanthanide-doped $BiVO_4$ phosphor for highly efficient upconversion luminescence and temperature sensing

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Supporting information

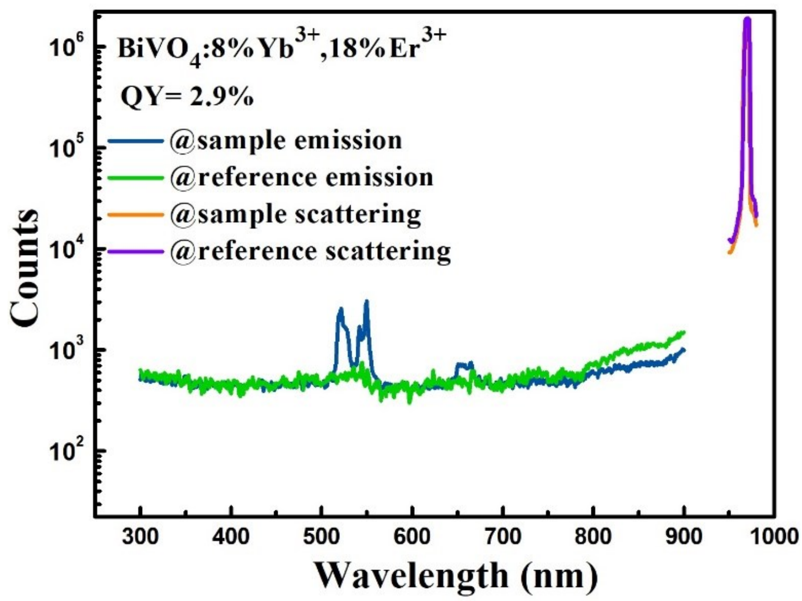

Figure S1. Absolute quantum yield (QY) measurements of the $BiVO_4$:8%Yb^{3+},18%Er^{3+} sample at excitation of 980 nm laser (power density: 38 W/cm^2) by using the fluorescence spectrometer (Edinburgh FS5) equipped with an integrating sphere. The standard $BaSO_4$ was used as the reference sample. Blue line: sample emission (E_{sam}), green line: reference sample emission (E_{ref}), yellow line: sample excitation scattering (L_{sam}), violet line: reference sample excitation scattering (L_{ref}). The QY was calculated based on the equation of QY= $[E_{sam} - E_{ref}] / [L_{ref} - L_{sam}]$ [1] [2].

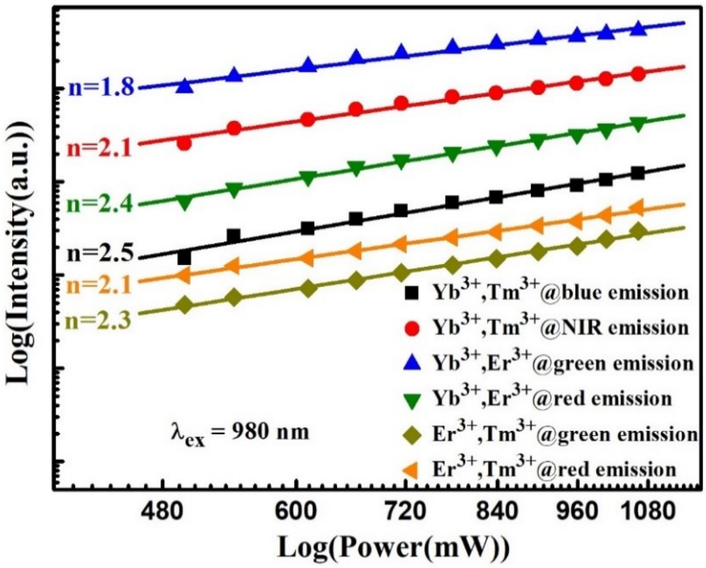

Figure S2. Logarithmic curves of luminescence integrated intensity (I) of $BiVO_4$ doped with Yb^{3+}/Tm^{3+}, Yb^{3+}/Er^{3+} and Er^{3+}/Tm^{3+} samples as a function of excitation power (P) under 980 nm pumping.

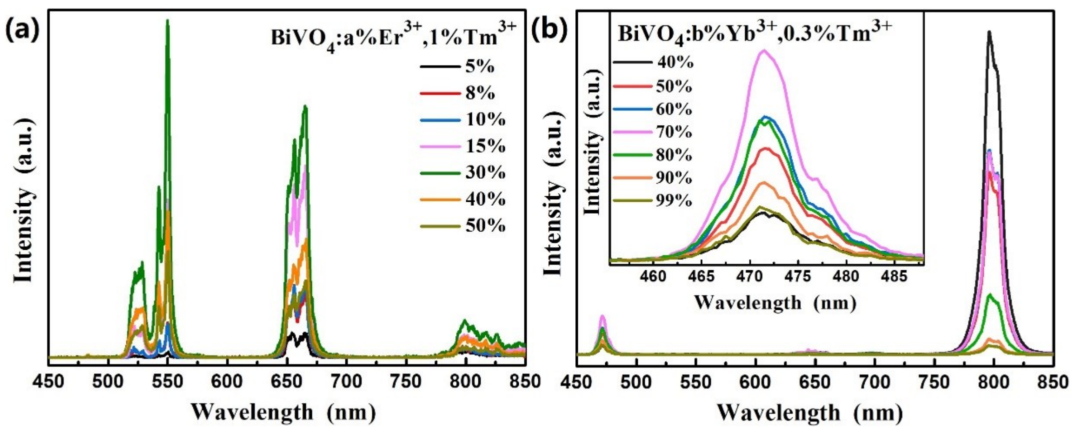

Figure S3. The UCL emission spectra of (a) $BiVO_4$:a%Er^{3+},1%Tm^{3+} (a = 5, 8, 10, 15, 30, 40, 50) and (b) $BiVO_4$:b%Yb^{3+},0.3%Tm^{3+} (b = 40, 50, 60, 70, 80, 90, 99) (The inset is the enlarged view of blue emission) at 980 nm excitation.

As shown in Figure S3a, the UCL intensity of the Er^{3+}/Tm^{3+} ions doped $BiVO_4$ sample increases gradually to a maximum value as the increasing of Er^{3+} doping concentration with Tm^{3+} concentration fixed at 1%, and then decreases after Er^{3+} doping content more than 30% at excitation of 980 nm. Similarly, the blue emission of Yb^{3+}/Tm^{3+} co-doped sample increases first and then decreases when increasing Yb^{3+} concentration at a fixed Tm^{3+} concentration of 1%, and the optimized doping concentrations of Yb^{3+} is found to be 70% as shown in Figure S3b.

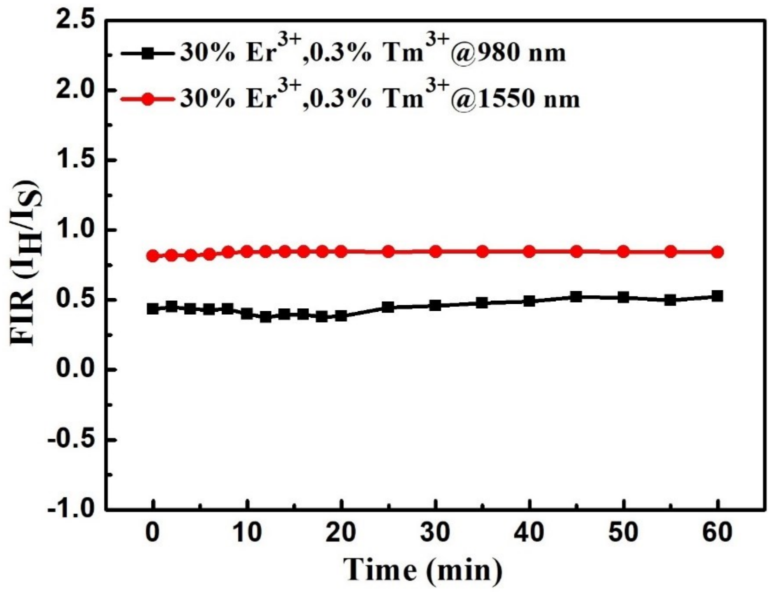

Figure S4. Dependence of FIR values on 980 nm and 1550 nm laser irradiation times for $BiVO_4$:30%Er^{3+},0.8%Tm^{3+} samples.

The dependence of the FIR values of the two green emissions for $BiVO_4$:30%Er^{3+},0.8%Tm^{3+} sample on the laser irradiation times is shown in Figure S4. The low excitation power densities of 19 mW/mm^2 and 23 mW/mm^2 for 980 nm and 1550 nm lasers, respectively, were chosen to obtain

UCL spectra. The FIR curves of the two samples are relatively flat within the irradiation time of one hour, meaning that the effect of irradiation power densities used in this work on the FIR measurements can be neglected.

[1] J. C. de Mello, H. F. Wittmann, R. H. Friend, An improved experimental determination of external photoluminescence quantum efficiency, Adv Mater. 9 (1997) 230–232. https://doi.org/10.1002/adma.19970090308.

[2] R. E. de Araujo, C. T. Dominguez, Absolute and relative methods for fluorescence quantum yield evaluation of quantum dots, Methods Mol Biol. 2 (2020) 37–51. https://doi.org/10.1007/978-1-0716-0463-2_2.