Electronic Supplementary Material (ESI) for Journal of Materials Chemistry B.

Production of a Fluorescence Resonance Energy Transfer (FRET) Biosensor Membrane for MicroRNA Detection

Yike Fu[a], Tong Chen[a], Gang Wang[a], Tongxu Gu[a], Congkun Xie[a], Jie Huang[b], Xiang Li[a]*, Serena Best[c], Gaorong Han[a]*

[a] *State Key Laboratory of Silicon Materials, School of Materials Science and Engineering, Zhejiang University, Hangzhou, Zhejiang 310027, P. R. China.*

[b] *Department of Mechanical Engineering, University College London, London WC1E 7JE, UK.*

[c] *Department of Materials Science and Metallurgy, University of Cambridge, Cambridge CB3 0FS, UK.*

** E-mail: xiang.li@zju.edu.cn; hgr@zju.edu.cn*

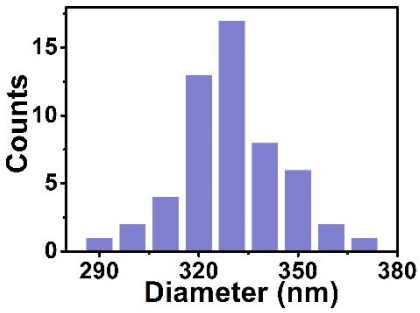

Figure S1 Diameter distribution of CaF_2:Yb,Ho nanoparticles processed hydrothermally at 180 °C for 24 h.

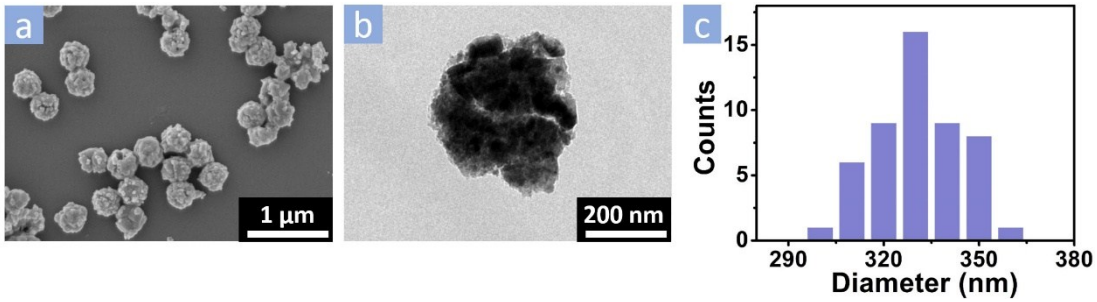

Figure S2 (a) SEM, (b) TEM and (c) diameter distribution of CaF_2:Yb,Ho nanoparticles calcined at 700 °C for 4 h.

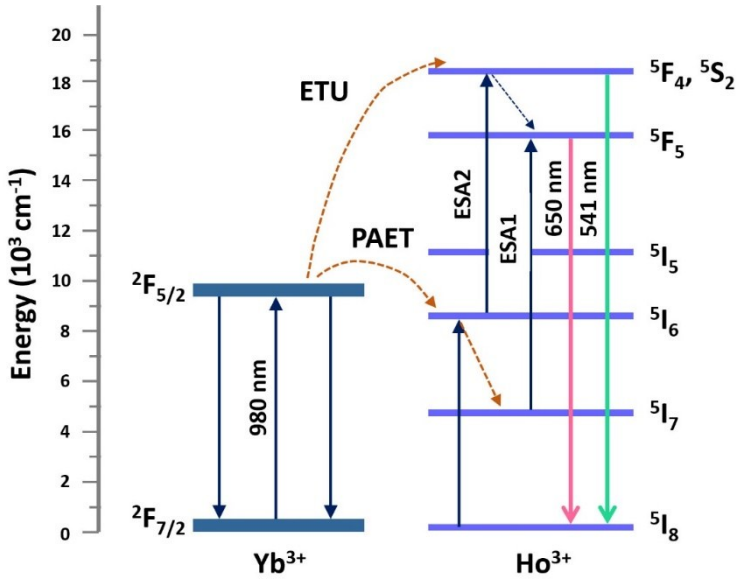

Figure S3 Simplified energy level scheme of Yb^{3+}/Ho^{3+} ions with mechanisms of energy transfer under excitation of 980 nm NIR. After ground state absorption of Yb^{3+} ion, the Ho^{3+} at $^5I_6$ level ion is populated in result of phonon-assisted energy transfer (PAET). Short lifetime of this multiplet leads to rapid nonradiative relaxation to metastable $^5I_7$ level. Subsequently, the excited ions gathered on this level absorb energy from pump radiation and populated to $^5F_5$ level ($^5I_7$-$^5F_5$ transition) through excited state absorption (ESA1) process. In the next step, the $^5F_4$ ($^5S_2$) was populated in consequence of the energy transfer with upconversion (ETU) from the excited Yb^{3+} ion and with second excited state absorption (ESA2). Finally, the green and red emissions can be generated at the $^5F_4/^5S_2$ state and $^5F_5$ state by radiative decays to the ground $^5I_8$ state with the wavelengths of 541 nm and 650 nm, respectively [1, 2].

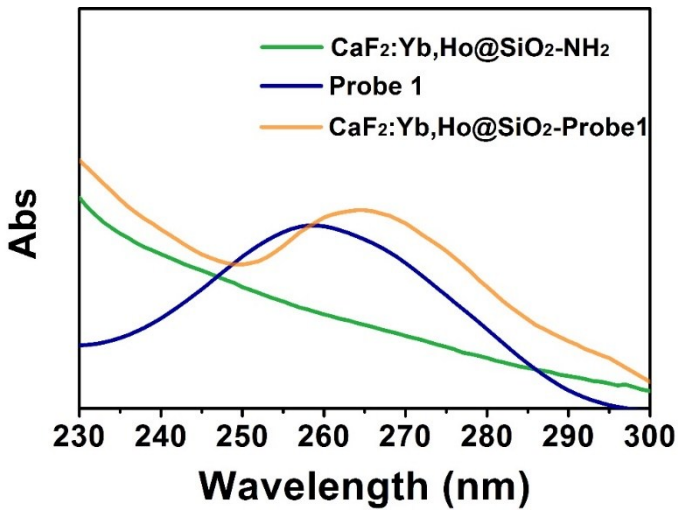

Figure S4 UV-vis absorption of CaF_2:Yb,Ho@SiO_2-NH_2, Probe 1 and CaF_2:Yb,Ho@SiO_2-Probe 1 conjugation.

References

1. C. Guanying, L. Haichun, S. Gabriel, L. Huijuan and Z. Zhiguo, *Nanotechnology*, 2009, **20**, 385704.
2. J. Zmojda, M. Kochanowicz, P. Miluski, J. Dorosz, J. Pisarska, W. A. Pisarski and D. Dorosz, *J. Lumin.*, 2016, **170**, 795-800.