Supporting Information

Multimodal bioimaging using rare earth doped Gd_2O_2S: Yb/Er phosphor with upconversion luminescence and magnetic resonance properties

G. Ajithkumar[a1], Benjamin Yoo[b], Dara E. Goral[b], Peter J. Hornsby[b], Ai-Ling Lin[c], Uma Ladiwala[d]
Vinayak P. Dravid[e] and Dhiraj K Sardar[a]
[a]*Department of Physics and Astronomy, University of Texas at San Antonio, San Antonio, TX 78249*
[b]*Department of Physiology and Barshop Institute,University of Texas Health Science Center at San Antonio, San Antonio, TX 78245*
[c]*Research Imaging Institute, Barshop Institute and Department of Cellular & Structural Biology, University of Texas Health Science Center, 7703 Floyd Curl Drive, San Antonio, TX 78229*
[d]*UM-DAE Centre for Excellence in Basic Sciences, Health Centre Bldg, University of Mumbai, Kalina Campus, Mumbai 400098*
[e]*Department of Materials Science and Engineering,Northwestern University,2220 Campus Drive,Evanston, IL 60208-3108*

[1] Corresponding author email:akgsh@yahoo.com
Fax 2104584919

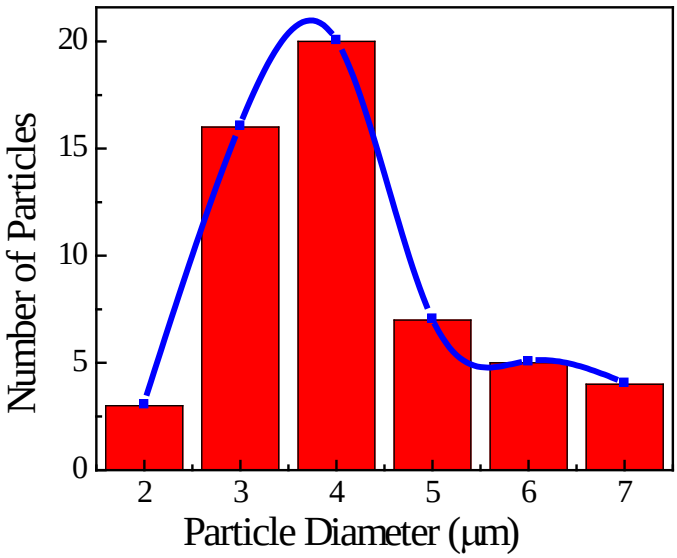


Figure S1.Particle size distribution obtained from SEM image analysis. Images were analyzed from different locations and the distributions obtained from over 200 particles.

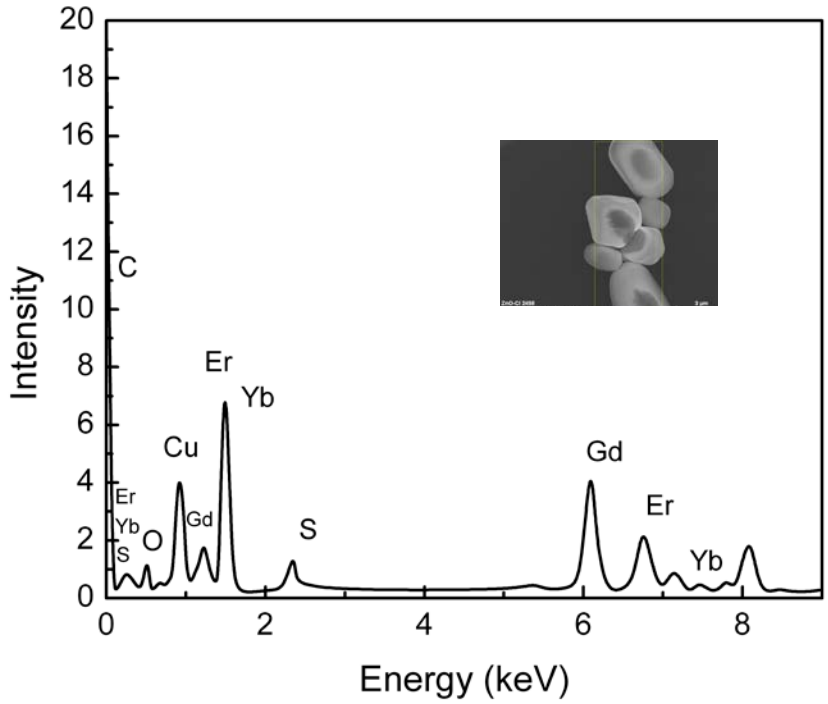


Figure S2.EDAX spectrum of the Gd_2O_2S: Yb/Er phosphor showing the elemental compositions. The C and Cu peaks originate from the carbon coated copper TEM grid. The inset shows the SEM image with square corresponding to the imaging location.

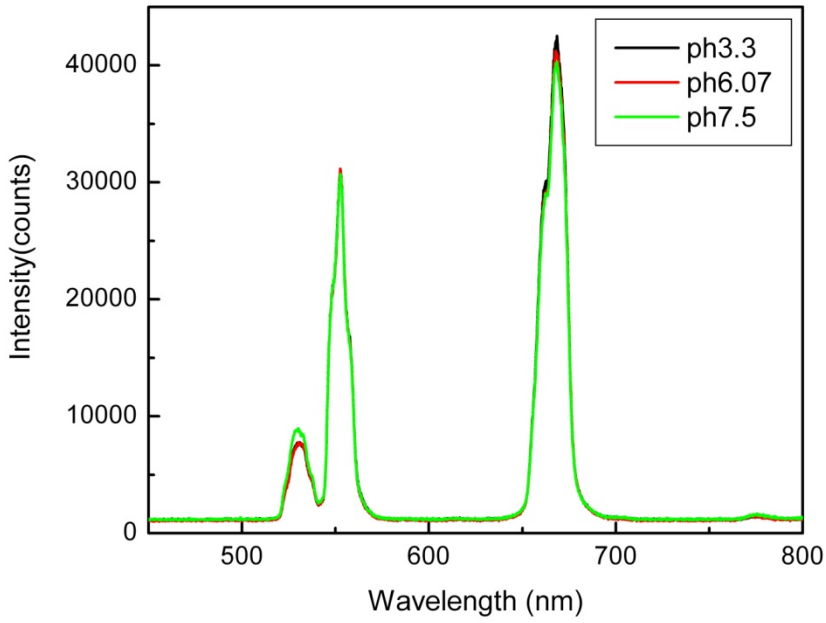


Figure S3.Upconcersion emission spectra in Gd2O2s:YbEr under different pH conditiions of the medium.

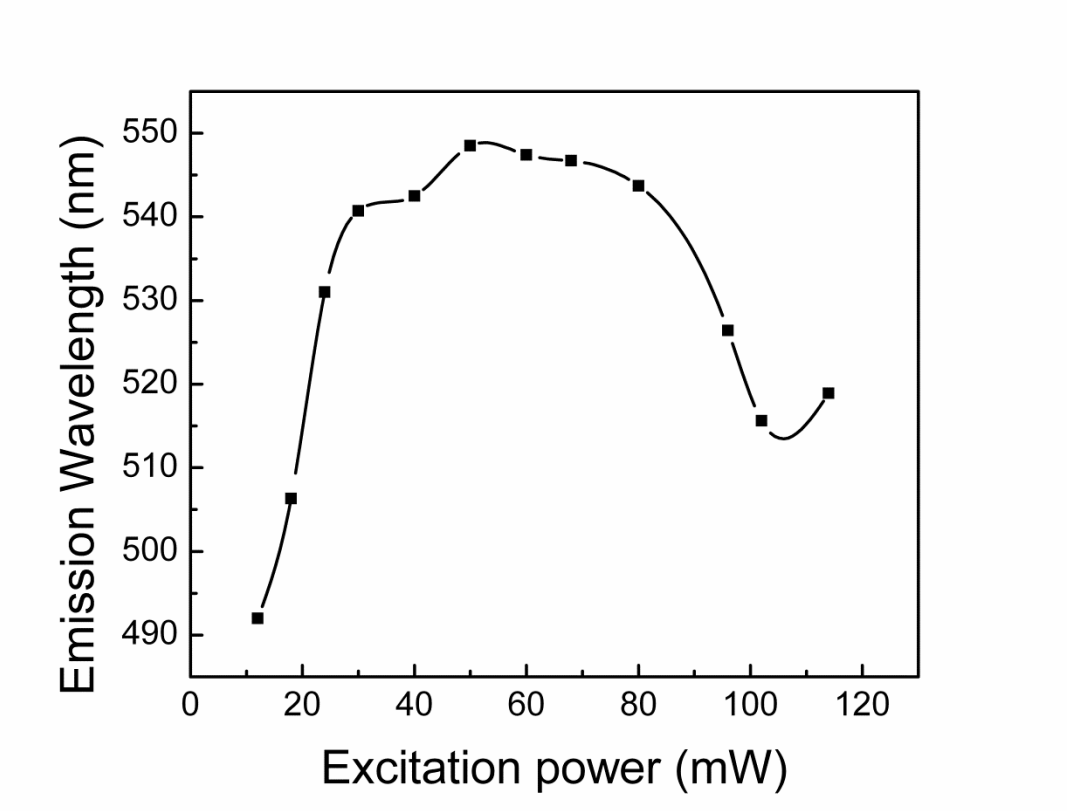


Figure S4.Color tuning behavior in Gd_2O_2S: Yb/Er under 980 nm laser excitation.

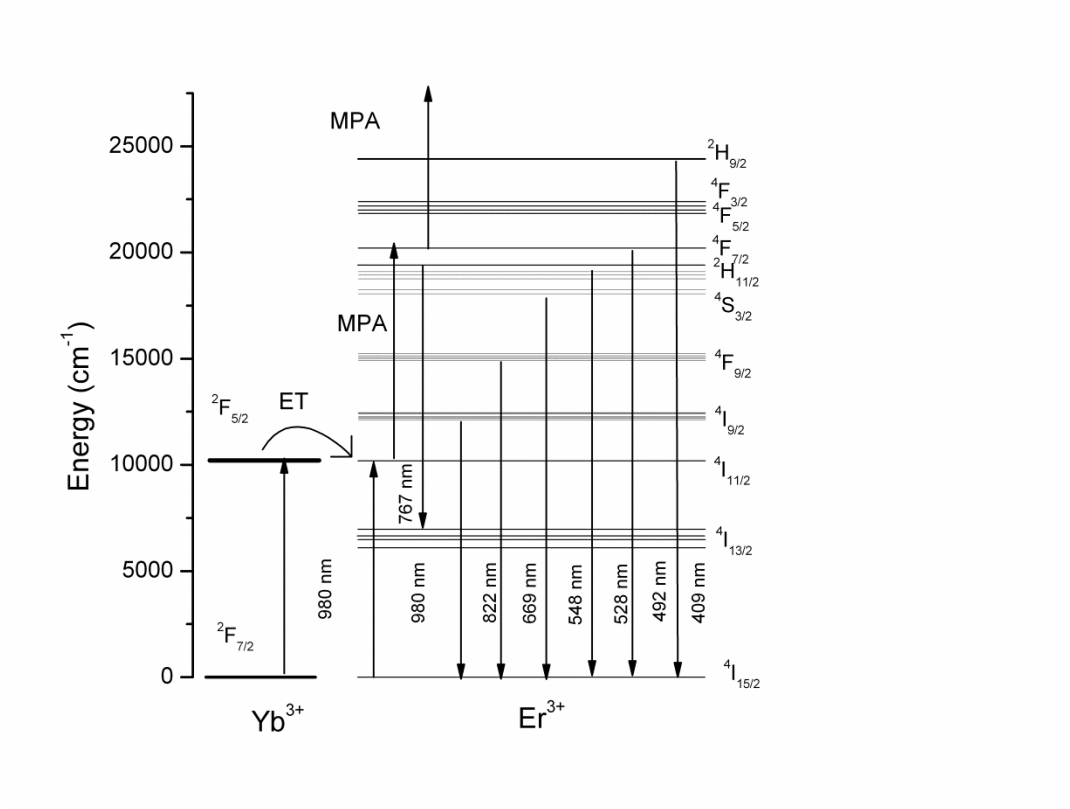


Figure S5.Energy level structure and excitation and de excitation mechanisms in the Gd_2O_2S: Yb/Er phosphor under 980 nm excitation. MPA- multiphoton absorption, ET-Energy transfer. All emission bands observed under 980 nm excitation are indicated.

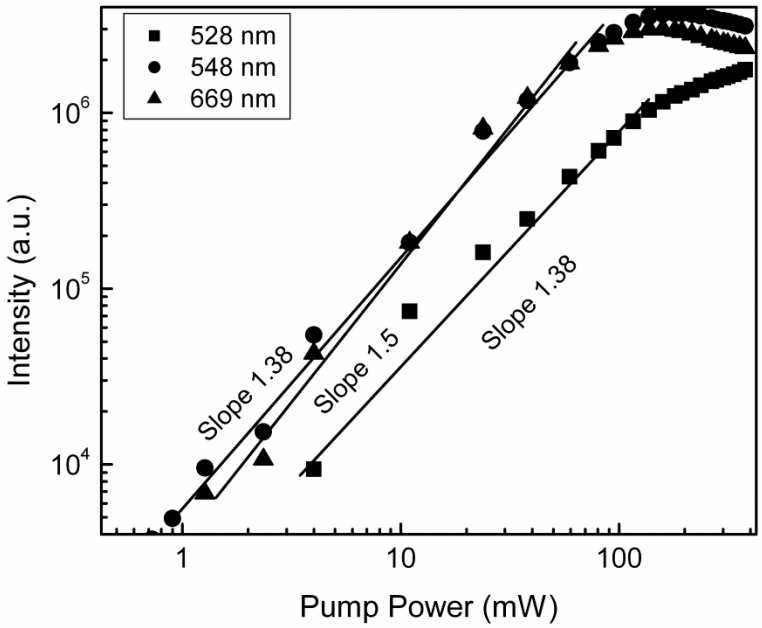


Figure S6.Pump power dependence of the green and red emission bands on 980 nm excitation power in Gd_2O_2S: Yb/Er phosphor.

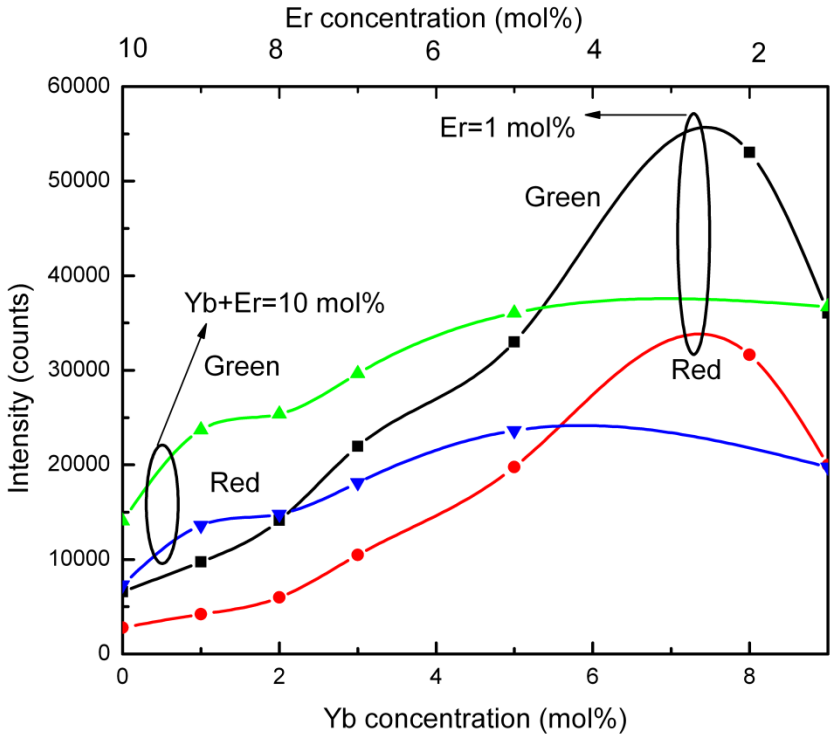


Figure S7.Variation of the red and green emission intensity with Yb and Er in Gd_2O_2S: Yb/Er phosphor. Top circles curves for Er =1mol% and bottom circles curves for Yb+Er =10 mol%.

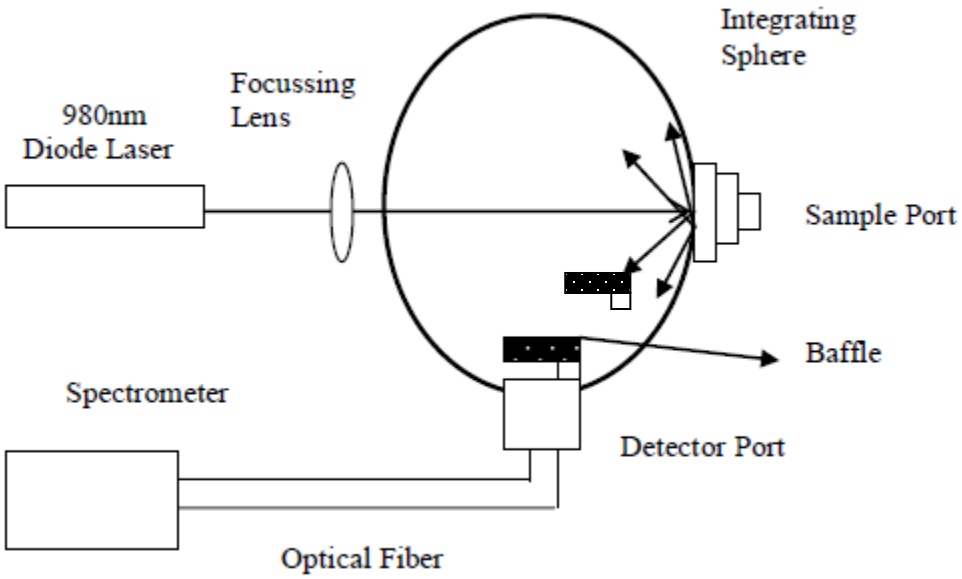
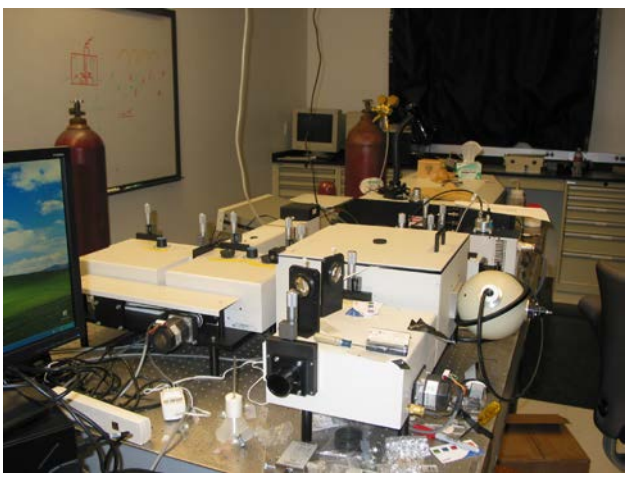


Figure S8.Schematic of the integrating sphere setup for measuring the quantum efficiency of the phosphor.



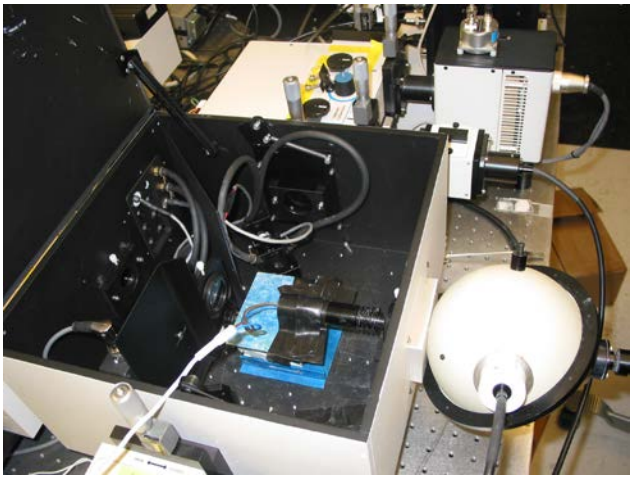


Figure S9(left).Photograph of the experimental setup illustrated in Figure S8.Right-Closeup view of the sphere and the diode laser inside the sample chamber.

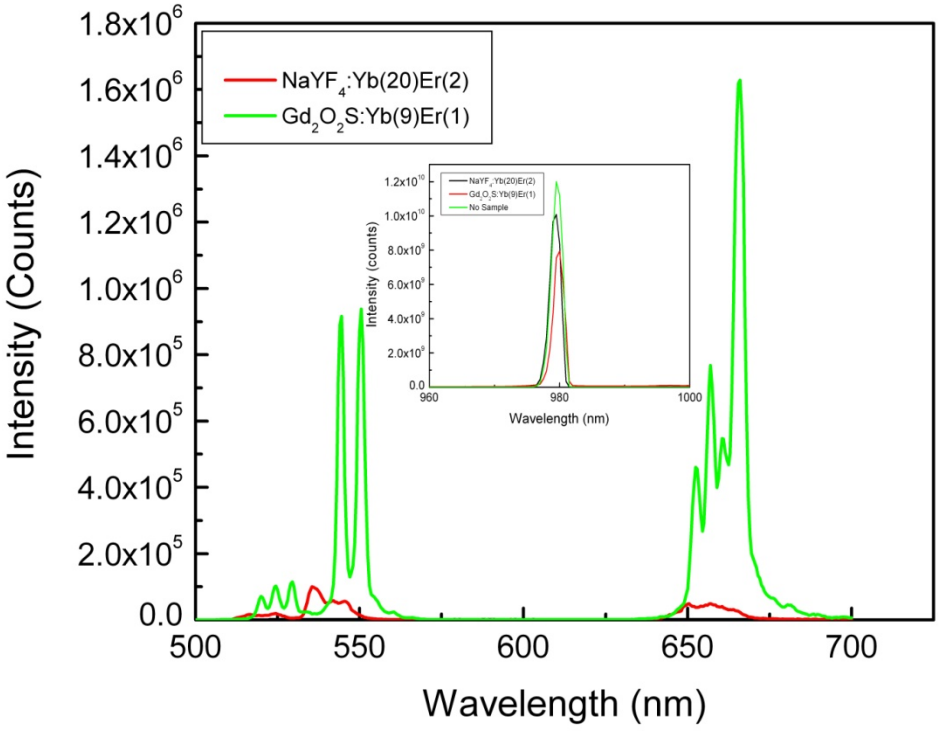


Figure S10. Comparison of the 980 nm excited upconversion emission spectra of $NaYF_4$: Yb (20%) Er (2%) and Gd_2O_2S: Yb (9) Er (1) phosphors collected with integrating sphere under identical conditions.The inset shows the 980 nm laser excitation profile.

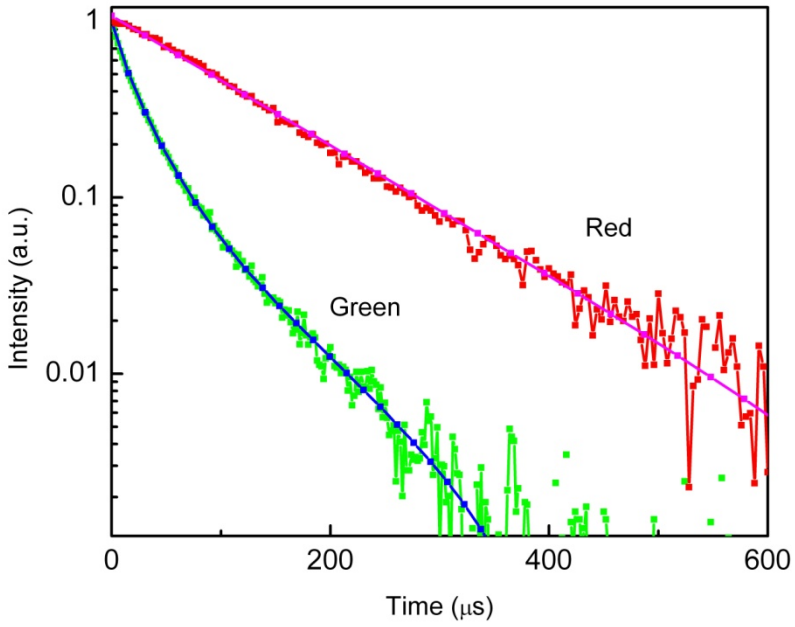


Figure S11. Fluorescence decay curves of the green and red emission in Gd_2O_2S: Yb (8) Er (1) phosphor.

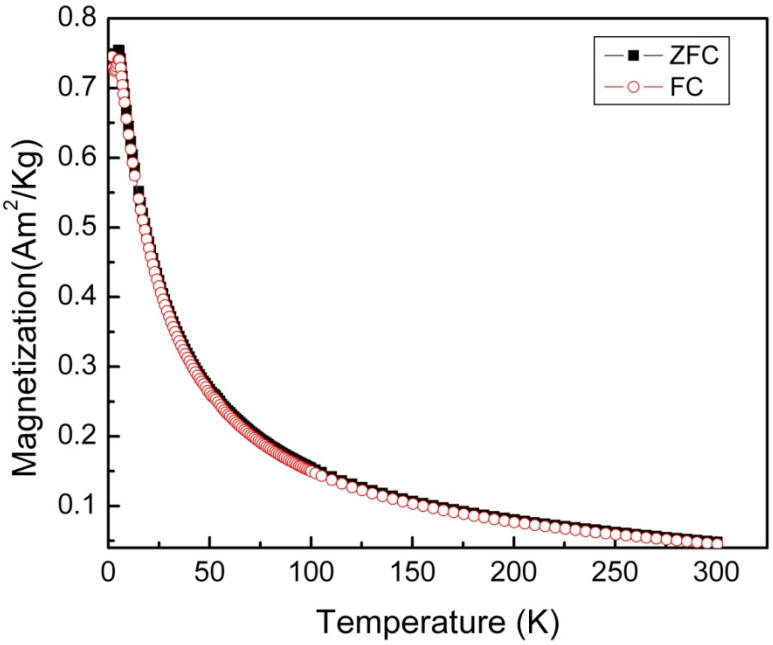


Figure S12 Zero field cooling(ZFC) and field cooling (FC) curves.

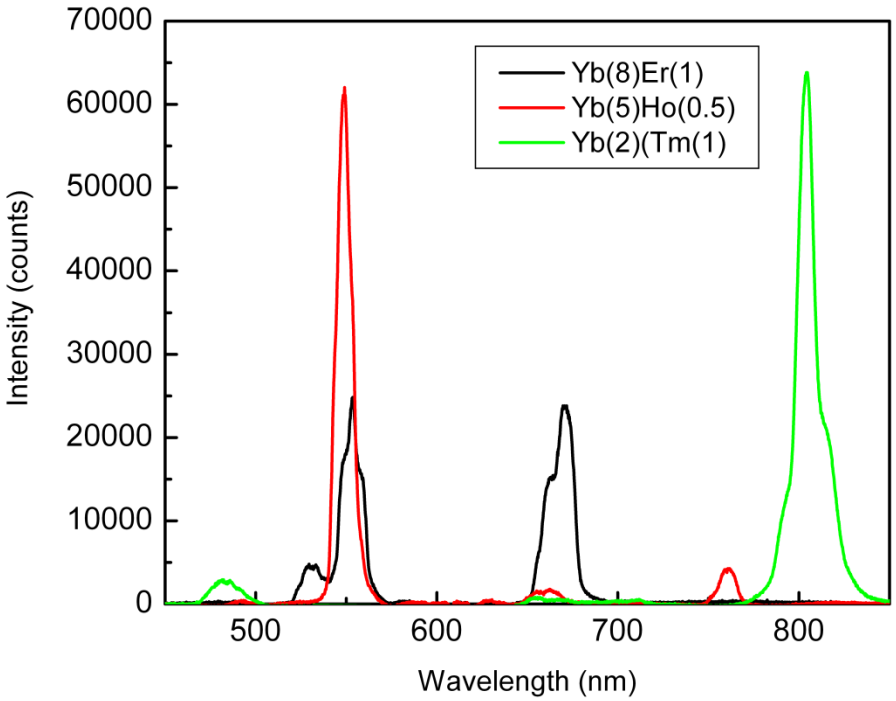


Figure S13. Comparison of the 980 nm excited upconversion emission spectral properties of Gd_2O_2S doped with various concentration of Yb/Er, YbHo and YbTm.

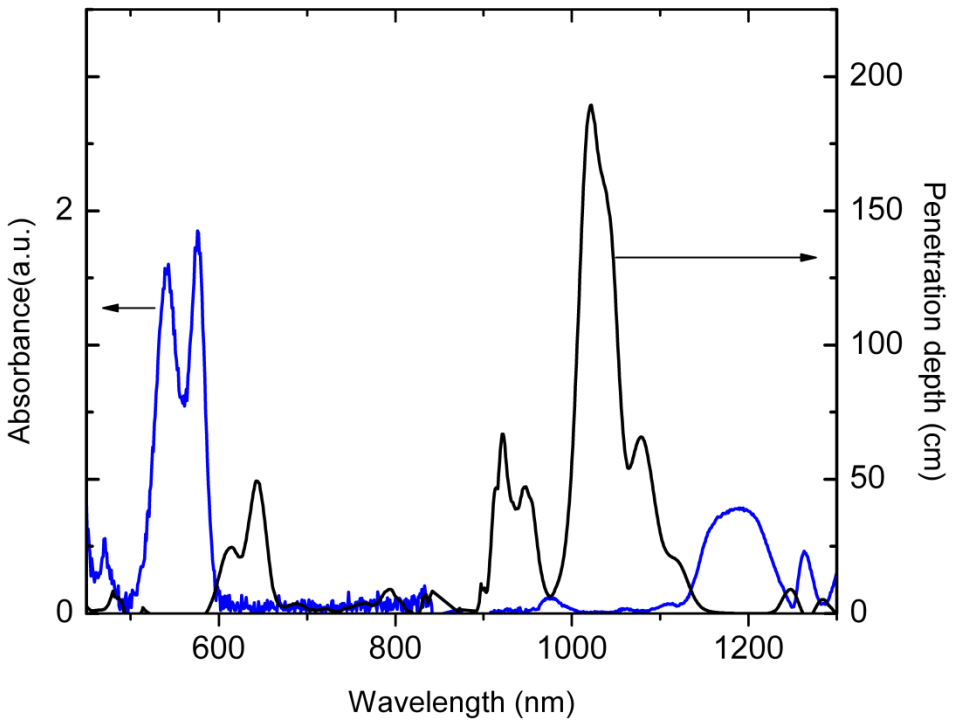


Figure S14.Absorption spectrum of pork muscle tissue and the calculated penetration depth spectrum. Penetration depth was calculated without considering the scattering components of the tissue.