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

Electronic Supplementary Information†(ESI)

Highly luminescent dual mode rare-earth nanorod assisted multi-stage excitable security ink for anti-counterfeiting applications

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Fig. S1 Commercially available PVC gold medium used for ink preparation. The use of PVC gold medium is well known for screen printing which is major advantage in present case to choose PVC gold medium.

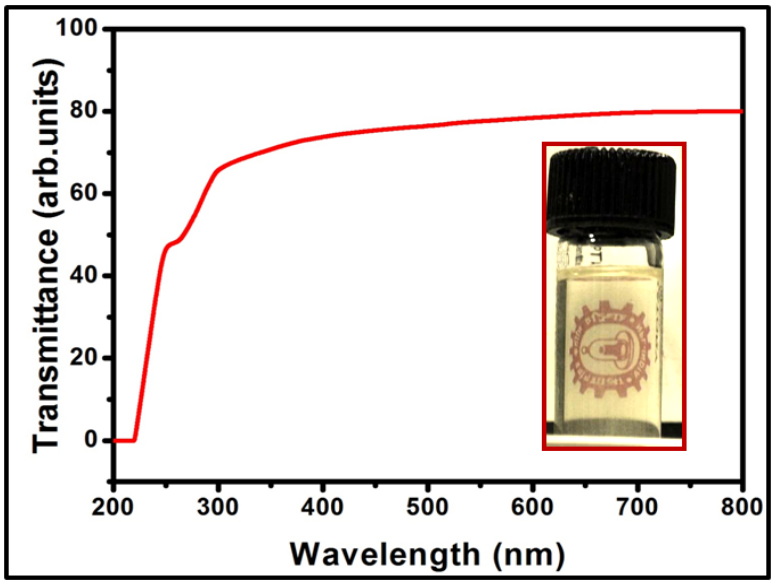

Fig. S2 Transmittance spectrum of Y_2O_3:Yb^{3+}, Er^{3+} nanorods in PVC gold medium and inset shows the transparent solution of Y_2O_3:Yb^{3+}, Er^{3+} nanorods dispersed in PVC gold medium which was highly stable for several hours with colloidal transparency ~81%.

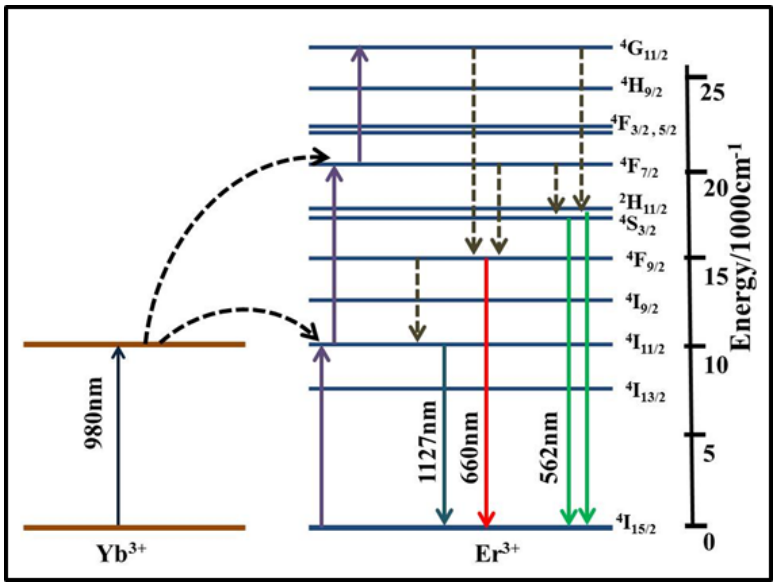

Fig. S3 Proposed energy level diagram for upconversion mechanism of Y_2O_3:Yb^{3+}, Er^{3+} nanorods.

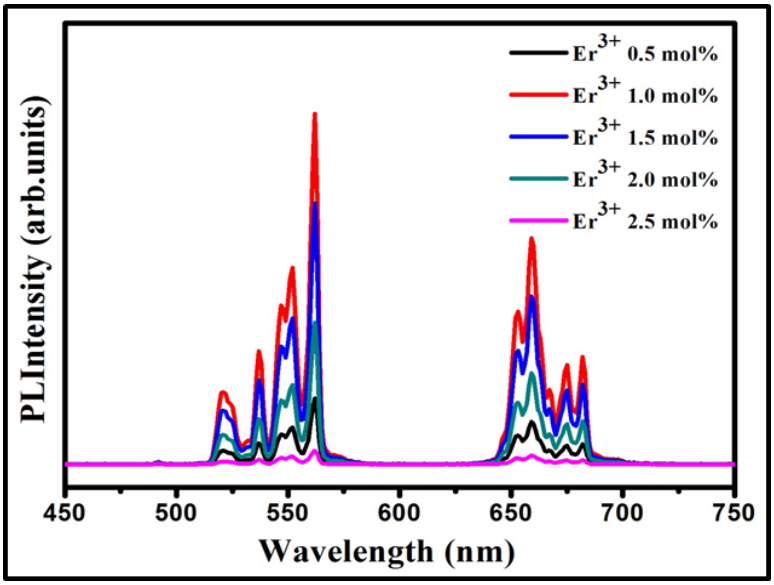

Fig. S4 Variation of PL intensity with the Er^{3+} concentration at fixed concentration of Yb^{3+} (2 mol%) in Y_2O_3:Yb^{3+}, Er^{3+} nanorods.

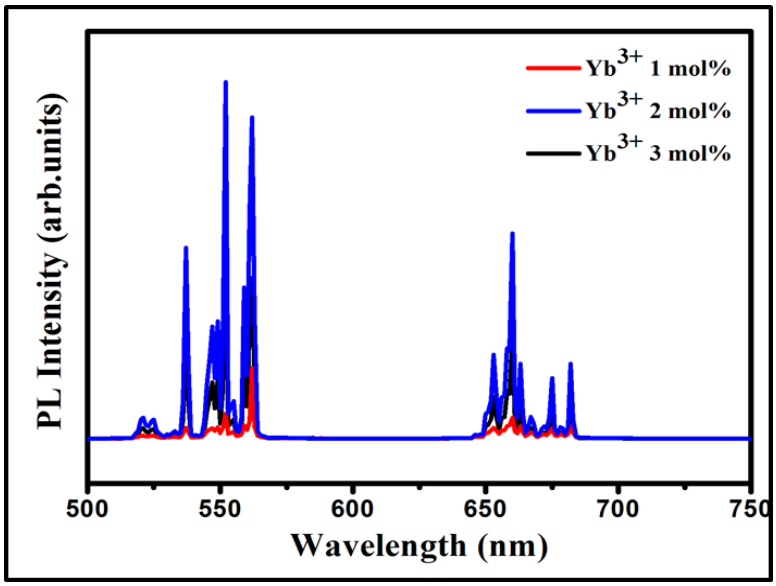

Fig. S5 Variation of PL intensity with the Yb^{3+} concentration at fixed concentration of Er^{3+} (1 mol%) in Y_2O_3:Yb^{3+}, Er^{3+} nanorods.

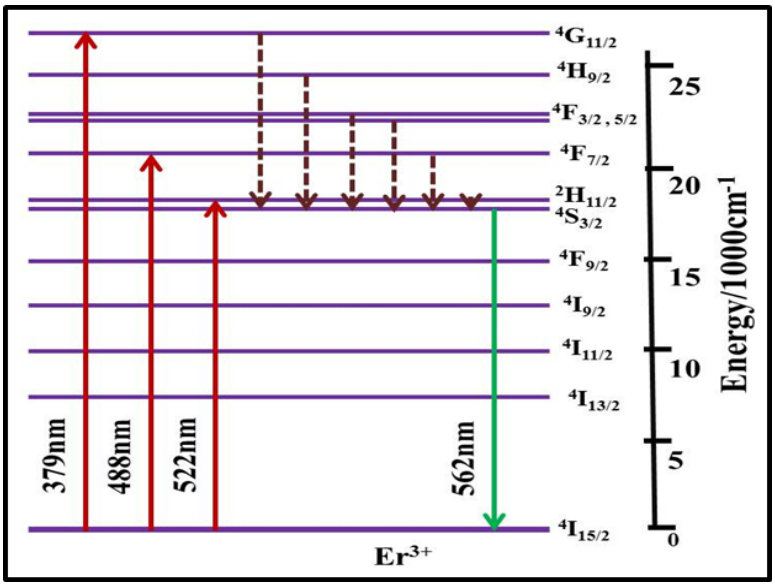

Fig. S6 Proposed energy level diagram for down-shift mechanism of Y_2O_3:Yb^{3+}, Er^{3+}nanorods.

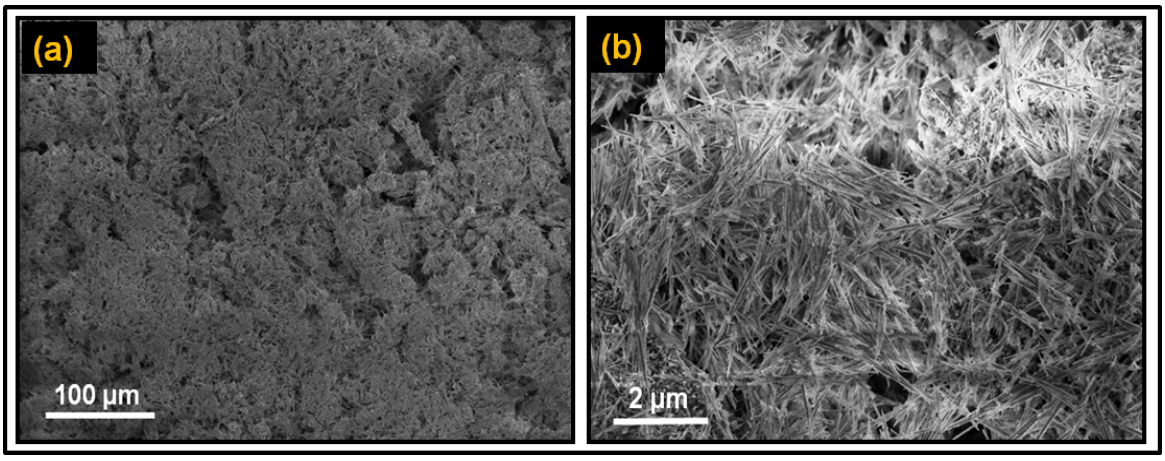

Fig. S7 (a) and (b) shows the SEM micrographs of $Y(OH)_3$:Yb^{3+}, Er^{3+}nanorods heated at 185^0C for 10 hours, where (b) is magnified version of Fig. (a). The micrographs are clearly demonstrating the nanorods grow at lower temperature with hexa-hydroxy formation phase.

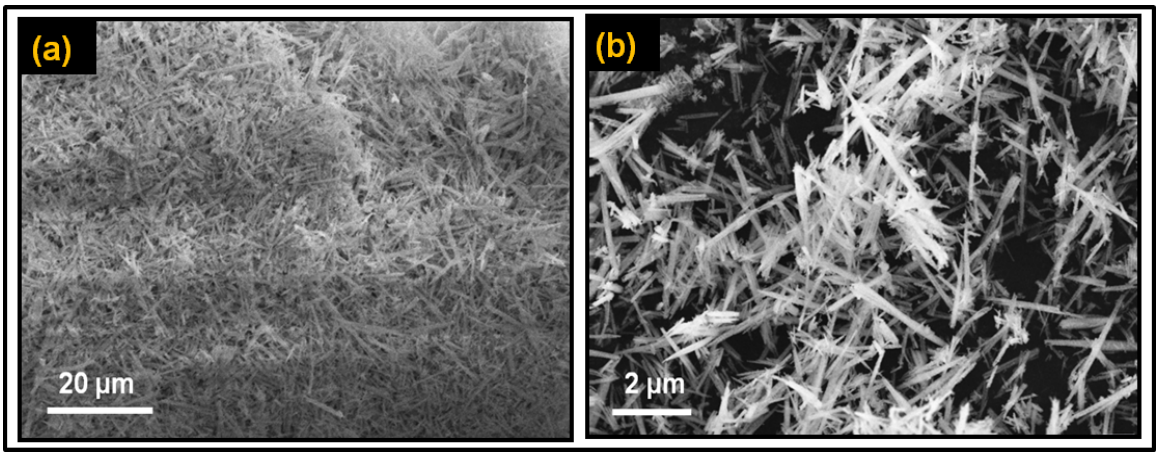

Fig. S8 (a) and (b) shows the SEM micrographs of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C for 3 hours, where (b) is magnified version of Fig. (a)

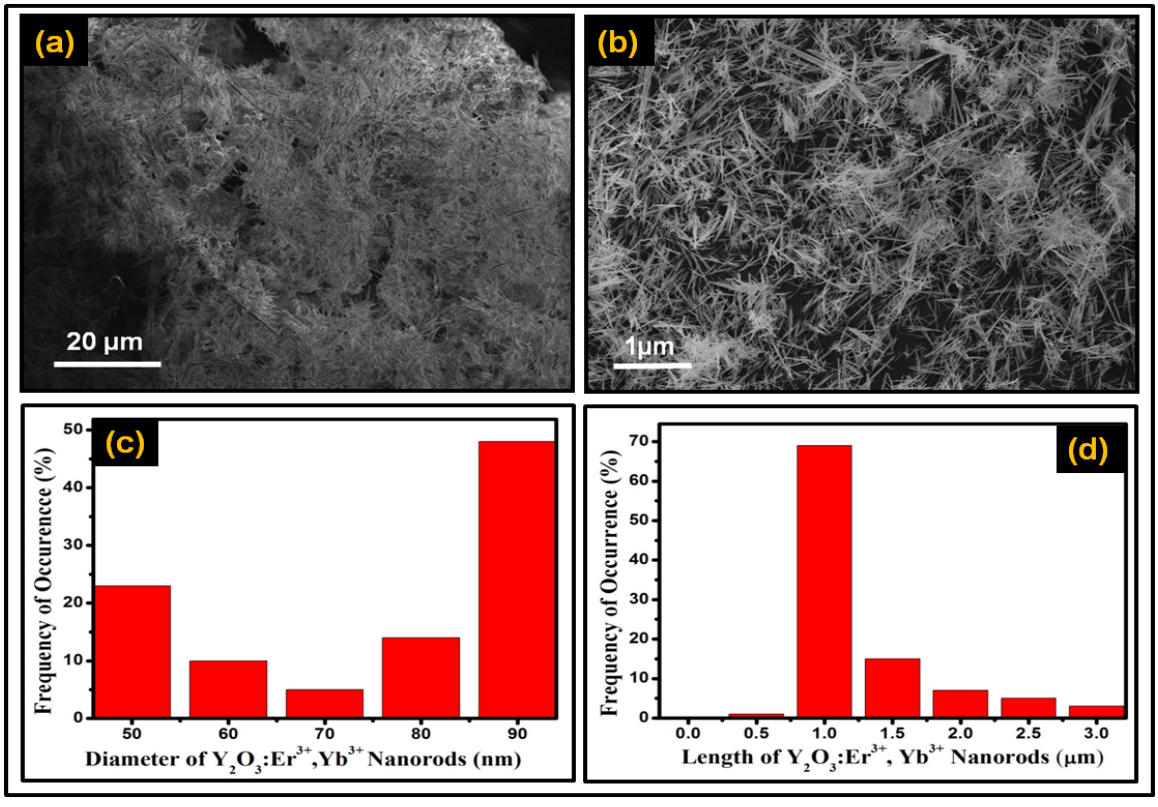

Fig. S9 (a) and (b) shows the SEM micrographs of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C for 6 hours, where (b) is magnified version of Fig. (a), which clearly demonstrates the high dense

structure of nanorods with almost uniform diameter. Fig (c) and (d) demonstrate the statistic histogram distribution for diameter and length of Y_2O_3:Yb^{3+}, Er^{3+}nanorods respectively.

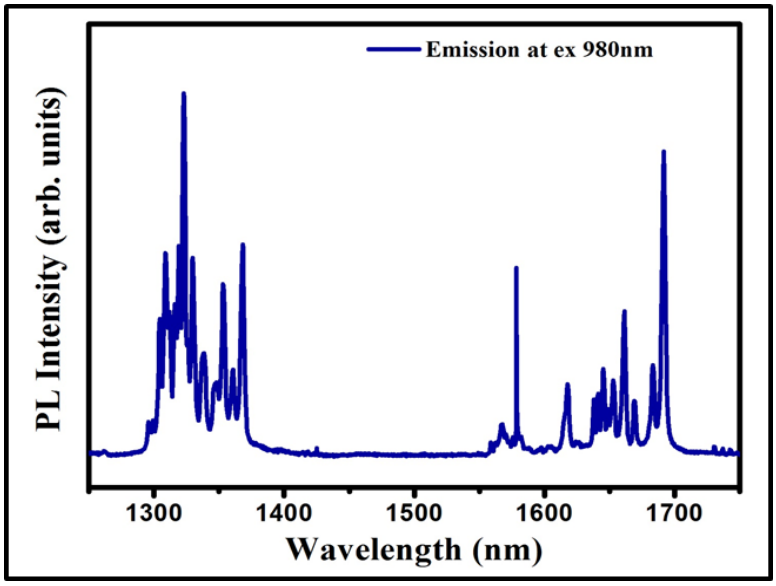

Fig. S10 Emission spectrum at excitation 980 nm of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C.

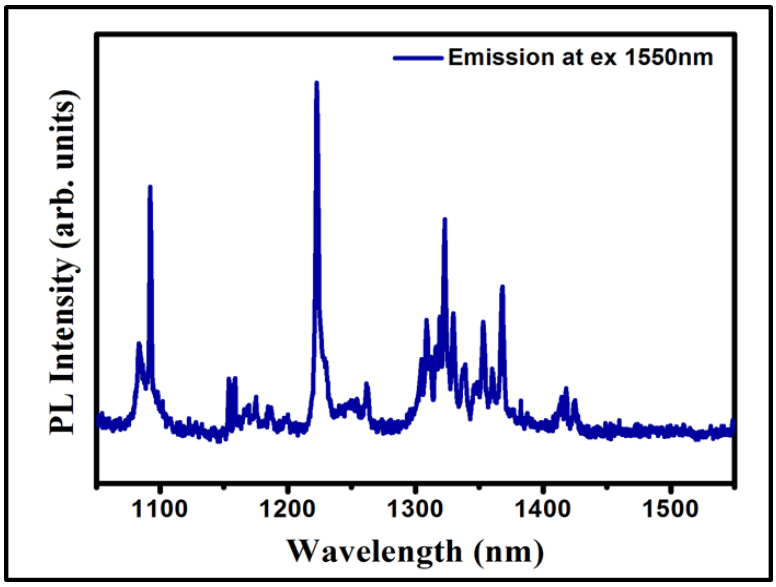

Fig. S11 Emission spectrum at excitation 1550 nm of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C.

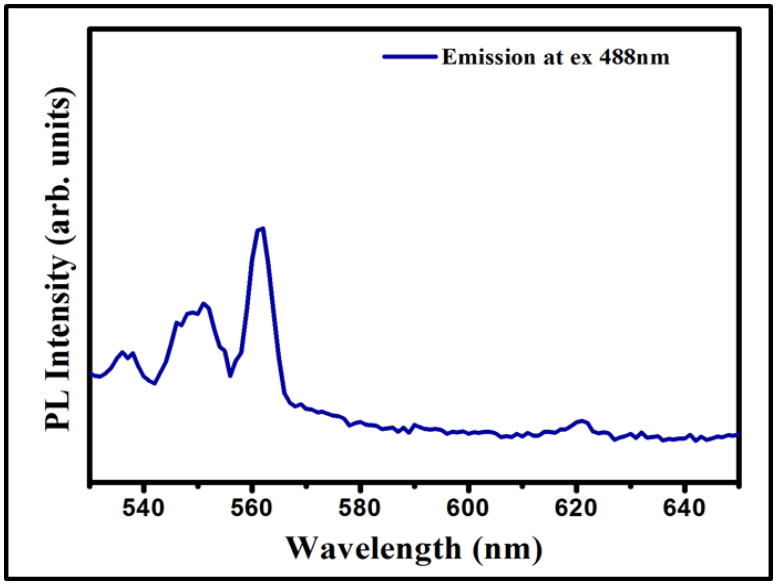

Fig. S12 Emission spectrum at excitation 488 nm of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C.

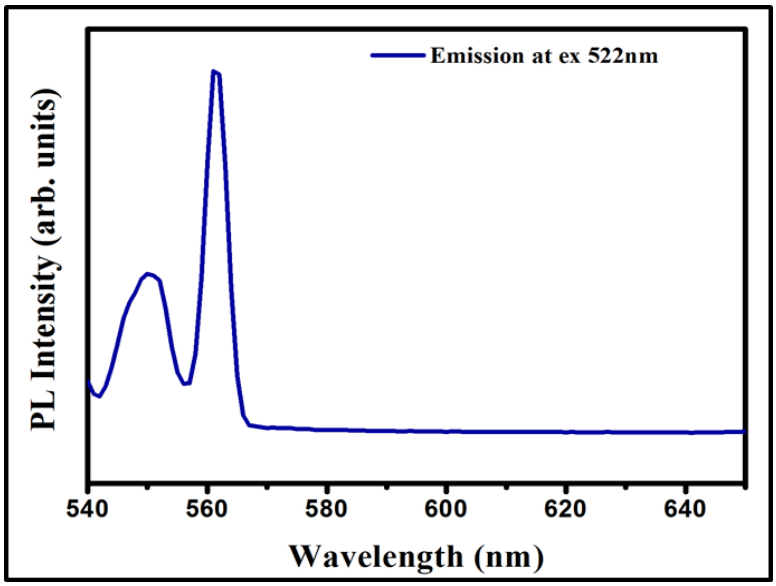

Fig. S13 Emission spectrum at excitation 522 nm wavelength of Y_2O_3:Yb^{3+}, Er^{3+}nanorods heated at 1000^0C.

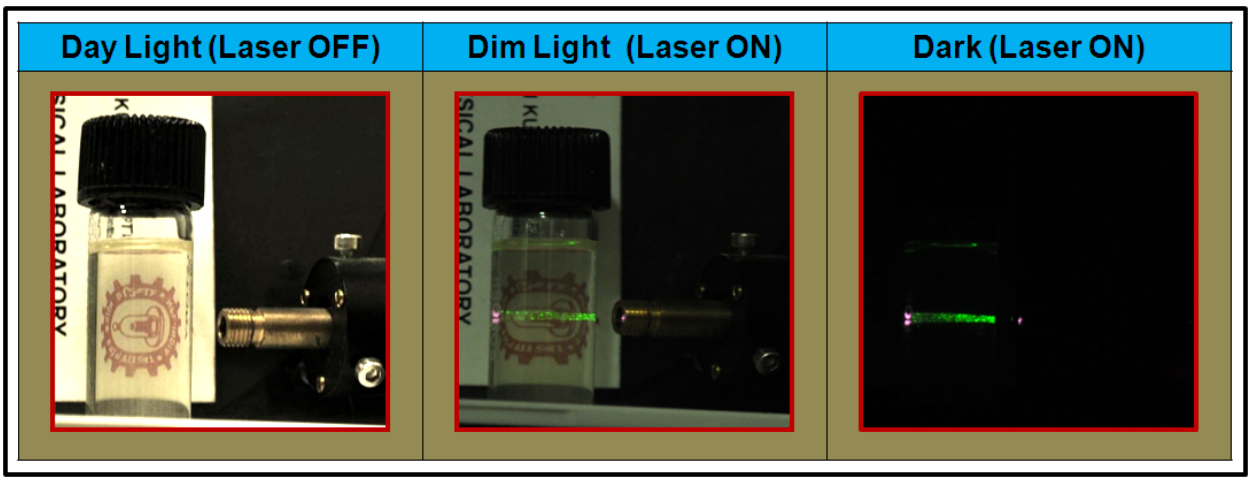

Fig. S14 Typical photographs of Y_2O_3:Yb^{3+}, Er^{3+} nanorods dispersed in PVC gold medium in different condition using 980 nm diode laser with beam diameter 3mm.

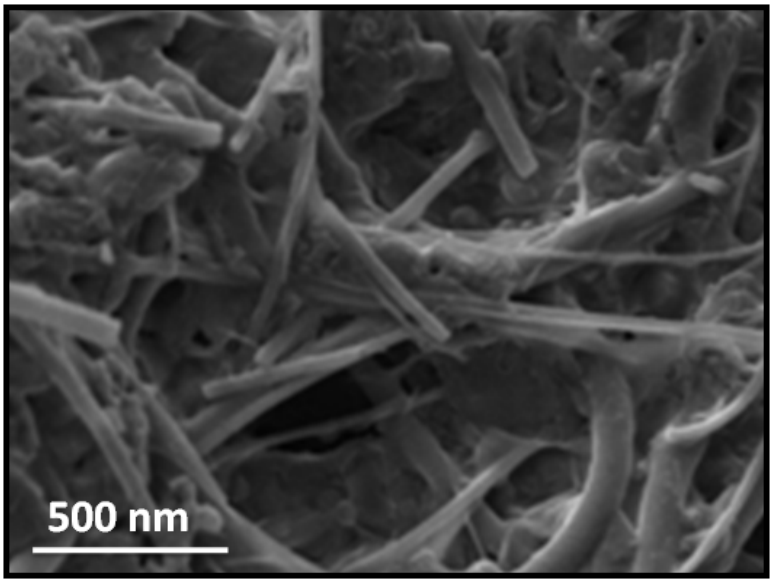

Fig. S15 SEM image of Y_2O_3:Yb^{3+}, Er^{3+}nanorods after its dispersion into PVC gold medium. The SEM result clearly exhibits infilling of nanorods in PVC gold medium matrix.