L.6: Er, Nd co-doped Y_2O_3 transparent ceramics: up-conversion and downshifting luminescence emitter

The use of transparent ceramics as a laser gain medium has increased due to the evolution of thin disk laser concept. This concept is based on thin disk laser design for diode pumped solid state lasers, which leads to generation of high power and high efficiency in compact devices. Successful fabrication and characterizations of transparent Er (1 at%), Nd (1at%) co-doped Y_2O_3 ceramics with transparency of ~78% (in 500-2000 nm range without Fresnel's correction) has been carried out at Laser and Functional Materials Division, RRCAT. This development involves nano-particle synthesis (by co-precipitation method) and sintering of Er, Nd co-doped Y_2O_3 ceramic pellets under high vacuum condition. The crystalline phase, particle size and element composition were confirmed by x-ray diffraction, scanning electron microscope, energy dispersive x-ray fluorescence techniques, respectively. Infrared to visible frequency upconversion and near infrared frequency downshifting properties of the fabricated ceramics were investigated. The up-conversion luminescence mechanisms involving energy transfer and non-radiative relaxation were analyzed. The up-conversion is because of the energy transfer from Nd^{3+} to Er^{3+} ion, which coexists in Y_2O_3 host. Additional dopants Zr^{4+} and La^{3+} were used to increase sinter-ability of transparent ceramic. It is expected that, the result evolved from this study will provide better understanding of up-conversion mechanism involved in Er, Nd co-doped host material.

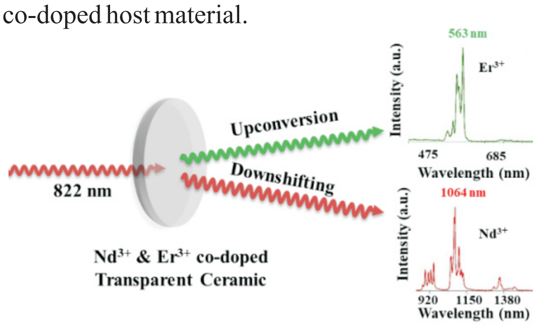

Fig. L.6.1: General strategy to achieve the upconversion and downshifting luminescence with Er, Nd co-doped transparent ceramic.

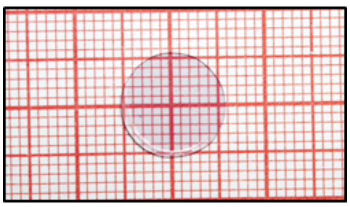

Fig. L.6.2: Image of sintered and polished Er^{3+}, Nd^{3+}:Y_2O_3 transparent ceramic.

Figure L.6.1 shows general strategy to achieve the upconversion and downshifting luminescence with Er/Nd codoped transparent ceramic. Figure L.6.2 and Figure L.6.3 show the image and the optical transmission spectra of Er^{3+}, Nd^{3+}:Y_2O_3 transparent ceramic, respectively.

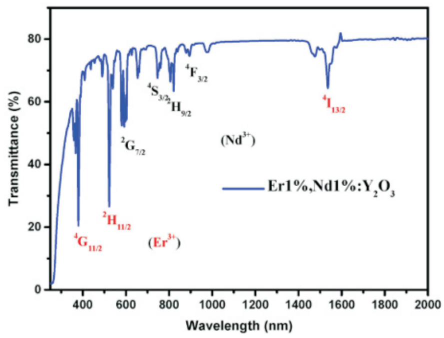

Fig. L.6.3: The optical transmission spectra of Er^{3+}, Nd^{3+}: Y_2O_3 transparent ceramic pellet.

The photoluminescence emission (Figure L.6.4) at both 563 nm (Er^{3+}:$^4S_{3/2}\rightarrow{}^4I_{15/2}$) and 1064 nm ($Nd^{3+}$:$^4F_{3/2}\rightarrow{}^4I_{9/2}$) on 822 nm ($Nd^{3+}$:$^4I_{9/2}\rightarrow{}^4F_{5/2}$) excitation proves potential of the ceramic material for dual mode efficient emitter at room temperature.

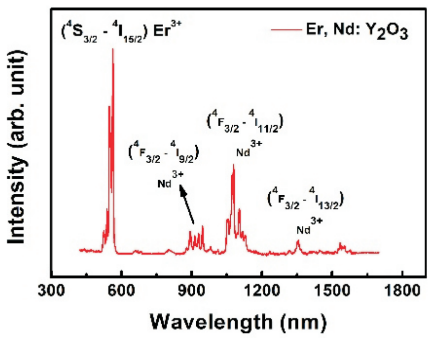

Fig. L.6.4: The PL emission spectra under 822 nm excitation of Er^{3+}, Nd^{3+}:Y_2O_3 transparent ceramics.

Further, the down-conversion luminescence emission at 1064 nm under UV excitation at 357 nm shows possible application of these transparent ceramics as spectral converter in photovoltaic application.

Reference: Pratik Deshmukh, S. Satapathy, M. K. Singh, M. P. Kamath, A. K. Karnal, Fabrication and characterization of Er, Nd co-doped Y_2O_3 Transparent Ceramic: A dual mode Photo-luminescence emitter, Journal of Alloys and Compounds 754, 32-38 (2018).

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