Broadband emission in Er-Tm codoped ZnO film: Energy transfer from ZnO host to rare earth ions

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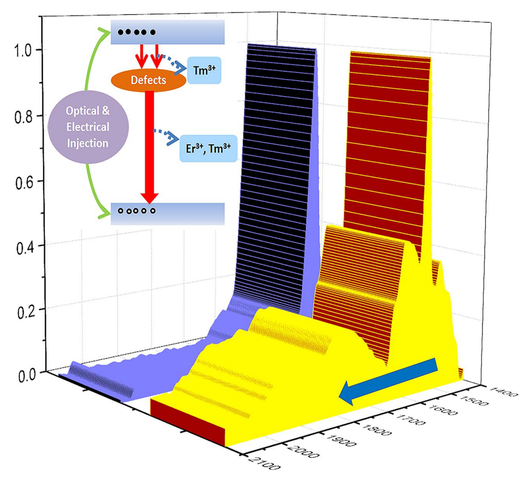
Motivation

- The increasing demand for information traffic requires the development of the wide band light sources and optical amplifiers urgently for full utilization of the 1400-1700 nm low-loss window band of silicon-based optical fibers.
- Overlapping emission bands from different rare earth (RE) ions can be used to provide a route to achieve such broadband emission. (Er: 1540 nm, Tm: 1400-1500, 1600-2100 nm)
- Infrared electroluminescence of the Er-Tm codoped semiconductors has never been studied.



Photoluminescence (PL)

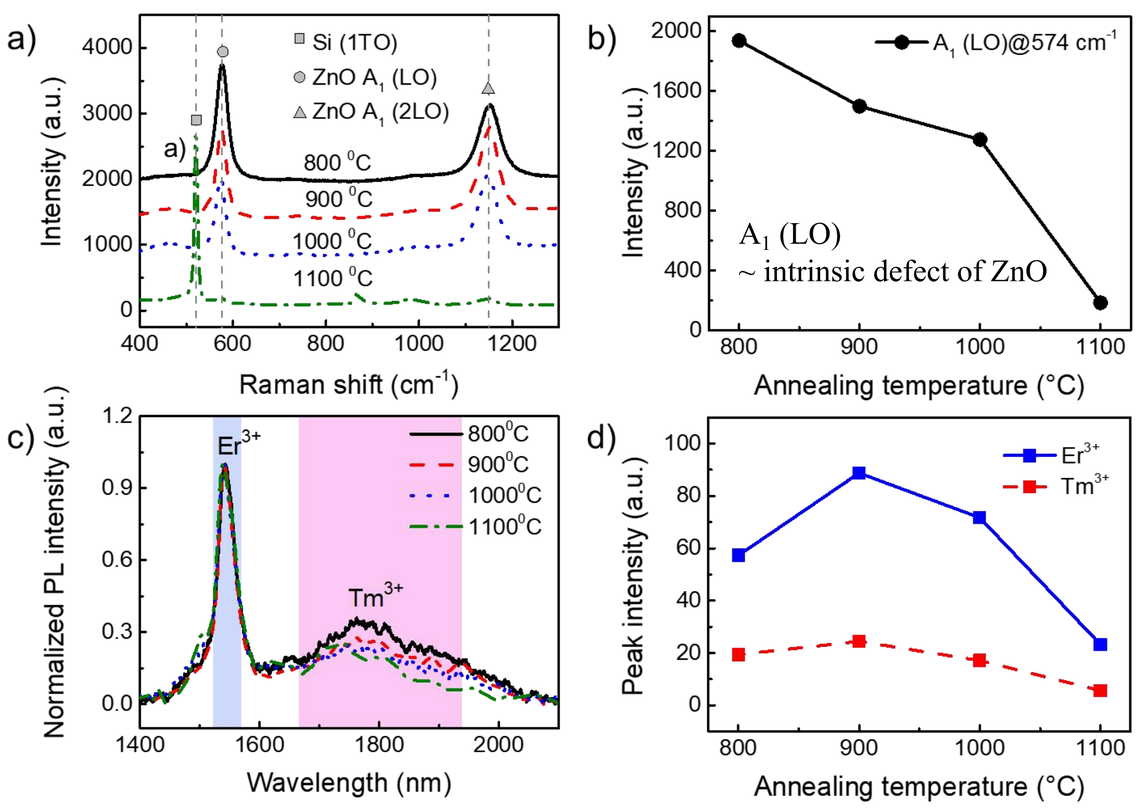


Figure 1 a) Raman spectra of the ETZO films. b) Annealing temperature dependence of the intensity of Raman peak at 574 cm^{-1}. c) RT PL spectra of the ETZO films each is normalized by the corresponding emission intensity of Er^{3+}. d) Annealing temperature dependencies of the intensity of the Er^{3+} and Tm^{3+} ions related emissions.

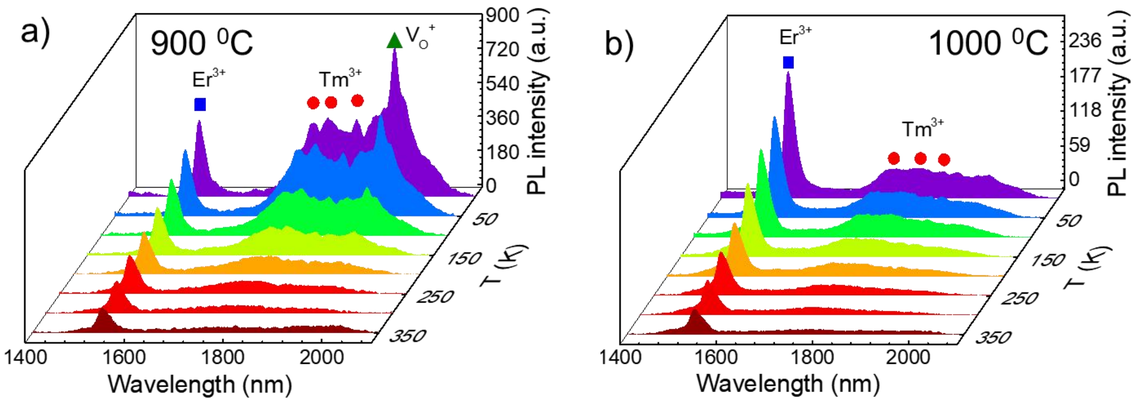


Figure 2 PL spectra of the ETZO films annealed at 900 a) and 1000 °C b) measured at different temperatures in the range of 10-350 K.

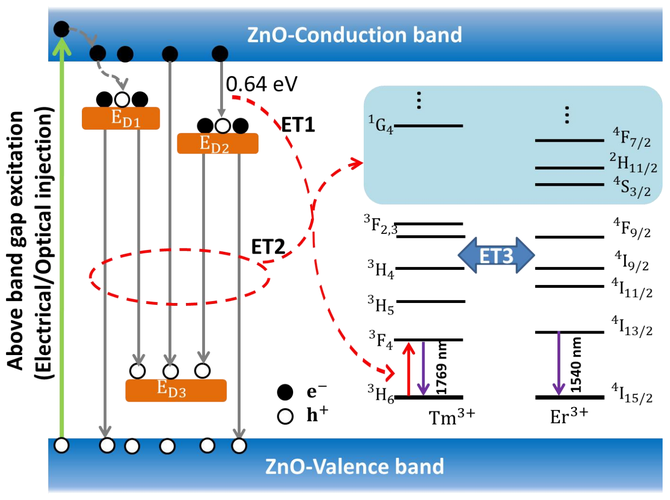


Figure 3 Schematic diagram for the proposed energy transfer processes in ETZO film.

ET1: ZnO → Tm^{3+}
ET2: ZnO → Er^{3+}, Tm^{3+}
ET3: Er^{3+} ↔ Tm^{3+}

Electroluminescence (EL)

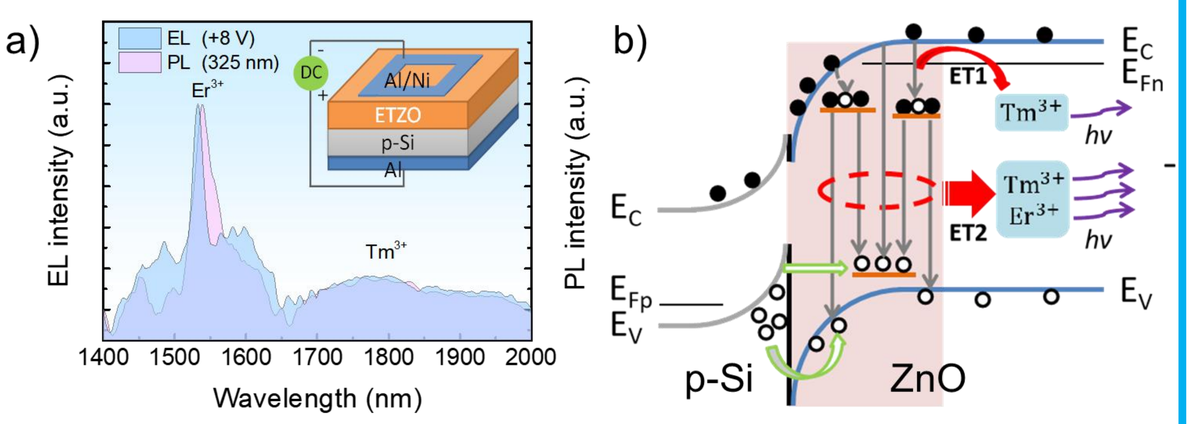


Figure 4 a) RT EL and PL spectra of Al/Ni/ETZO/p-Si/Al device. b) Schematic diagram for the energy band structure of the ETZO/p-Si device under sufficiently high forward bias voltage.

Conclusion

- 1400-2100 nm broadband emission (PL and EL), attributed to the radiative transitions of Er^{3+}: $^4I_{13/2} \rightarrow {}^4I_{15/2}$ and Tm^{3+}: $^3F_4 \rightarrow {}^3H_6$ was successfully achieved.
- The defect states of ZnO act as channels for the energy transfer from ZnO to Er^{3+} and Tm^{3+} ions by the recombination of the defect states.
- These results pave the way for the practical application of ETZO films as the broadband infrared optical amplifiers and light emitters.