Tailoring the $^4I_{9/2} \rightarrow {}^4I_{13/2}$ emission in Er^{3+} ions

Cyril Koughia[a], Chris Craig[b], Daniel W. Hewak[b] and Safa Kasap[a]

[a] *Department of Electrical and Computer Engineering*, *University of Saskatchewan*,

Saskatoon, Canada

[b] *Optoelectronics Centre*, *University of Southampton, Southampton, UK*

Email cyril.koughia@usask.ca

Many gas detection techniques rely on the absorption of light by specific absorption bands of the gas molecules. For example, methane (CH$_4$) has two strong absorption bands around 3.3 and 1.67 μm. The latter band seems to overlap the $^4I_{9/2} - {}^4I_{13/2}$ emission band of trivalent Er^{3+}, as shown in Figure 1; Er^{3+} is, of course, a popular rare-earth ion used various photonic device applications, including erbium doped optical fiber amplifier. In the present paper, we report that in some sulfide glasses (GeGaS and LaGaS) doped with 0.5 at.% of Er, the amplitude of $^4I_{9/2} - {}^4I_{13/2}$ emission band may reach up to 5% of the major $^4I_{13/2} - {}^4I_{15/2}$ emission band as shown in Figure 2. We investigate the possibility to "tailor" the $^4I_{9/2} - {}^4I_{13/2}$ emission band of trivalent Er^{3+} to better match the CH$_4$ absorption band. In particular, we examined the possibility of spectral shift by using a nephelauxetic effect by substituting for sulfur with oxygen or selenium. Surprisingly, these substitutions suppress the $^4I_{9/2} - {}^4I_{13/2}$ emission band rather than shift it. The present paper also discusses the possible mechanisms for this suppression.
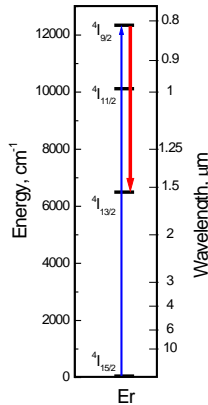

Figure 1. Optical transitions involved in the $^4I_{9/2} \rightarrow {}^4I_{13/2}$ emission from the Er^{3+} ion.
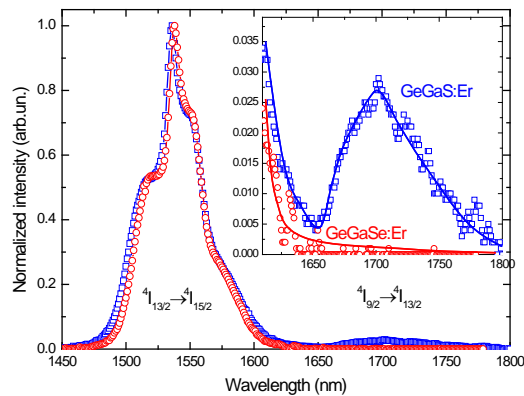
Figure 2. Experimental results on $^4I_{9/2} \rightarrow {}^4I_{13/2}$ and $^4I_{13/2} \rightarrow {}^4I_{15/2}$ emission bands in GeGaS (blue square) and GeGaSe (red circles) Er^{3+}-doped glasses. Excitation by 808 nm laser diode at room temperature. The inset shows the $^4I_{9/2} \rightarrow {}^4I_{13/2}$ emission bands magnified for clarity.