Local structure around erbium in the Er doped SiO_2/Si layers

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Motivation

Silicon nanostructures doped with Er^{3+} have been found as a good candidate for an infrared efficient emitter at telecommunication wavelength (1535 nm). Indirect excitation of Er^{3+} ions via energy transfer mechanism from nc-Si to erbium is involved in this optical emission. The key parameter in energy transfer process, which assures the efficient IR luminescence, is the distance between nc-Si (activator) and Er sensitize. However, the mechanism is still under debate.

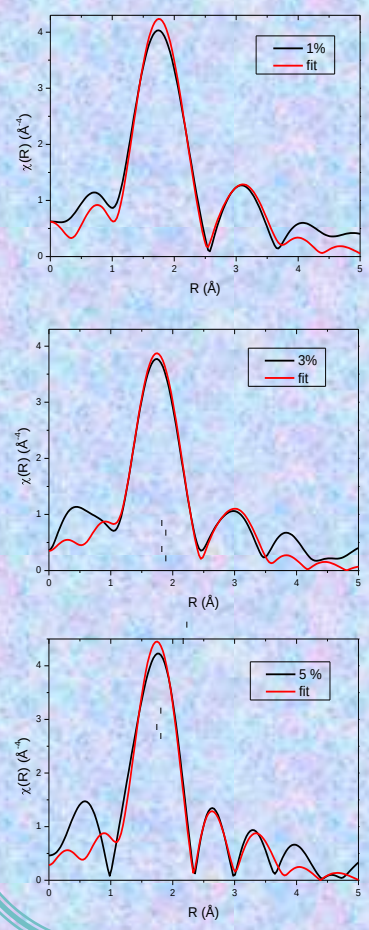
Sample preparation

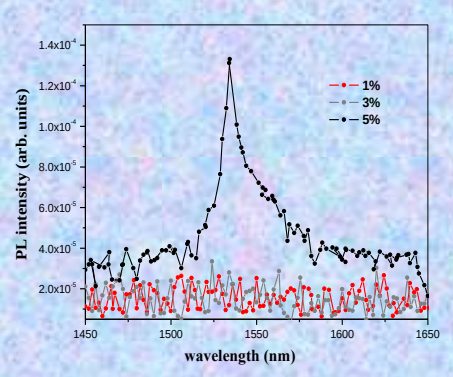
The SiO_2:Er/Si layers were fabricated by rf magnetron sputtering and subsequently annealed. One series with 1% of Er was annealed at 900°C by rapid thermal processing (RTP) and/or furnace annealing (FA). Next one with 1, 3 and 5% of Er was annealed only by FA at 1100°C.

Experimental

Photoluminescence spectra at room temperature of Er doped SiO_2 with a thickness of 50 nm. An Ar^+ laser line at 514.5 nm was applied as an excitation wavelength that is erbium off resonant.
The XAFS measurements were performed at Er L_3-edge at LISA beamline at ESRF (Grenoble, France).
EXAFS analysis was performed using Demeter code.

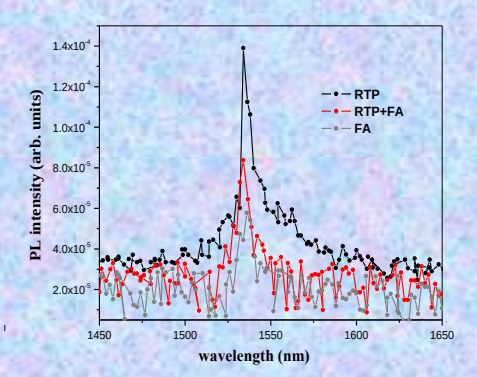
samples annealed at 1100°C

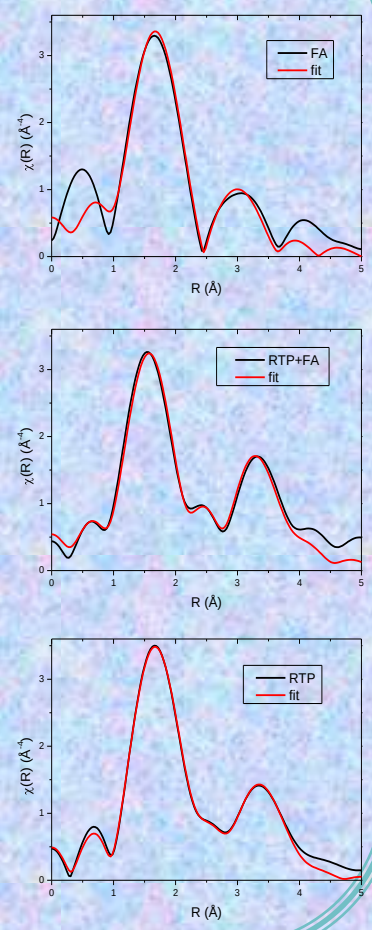




		N	R [Å]	σ^2[Å^2]
1%	Er-O	9	2.27(2)	0.016(1)
	Er-Si	4	3.67(4)	0.008(4)
3%	Er-O	9	2.26(2)	0.019(1)
	Er-Si	4	3.60(3)	0.013(4)
5%	Er-O	6	2.24(2)	0.010(1)
	Er-Si	4	3.43(5)	0.009(6)
	Er-Si	8	3.70(5)	0.017(7)

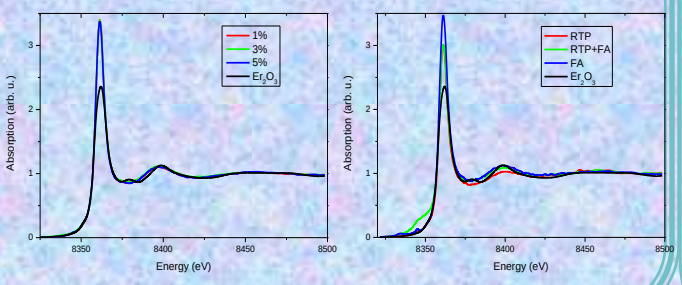
samples annealed at 900°C





1%		N	R [Å]	σ^2[Å^2]
FA	Er-O	8	2.22(1)	0.018(1)
	Er-Si	4	3.61(2)	0.012(2)
RTP+ FA	Er-O	6	2.14(2)	0.015(1)
	Er-O	4	2.87(4)	0.013(4)
	Er-O	8	3.87(3)	0.008(3)
RTP	Er-O	6	2.20(1)	0.013(1)
	Er-Si	4	3.22(1)	0.014(1)
	Er-O	8	3.89(1)	0.019(2)

XANES



Conclusions

* XANES analysis confirmed that in all samples Er ions are in 3+ state.
* In the series annealed at 1100°C only the sample with 5% of Er exhibits PL signal. This is followed by the decreasing of the bond lengths and N within the series.
* In the series annealed at 900°C all samples show PL signal. However, the strongest one can be seen for the sample annealed by RTP. The nearest structure differs between the samples within the series.
* Sample with 1% of Er annealed by FA at 900°C shows small PL signal. Similar annealing at 1100°C completely quenches PL signal. In this case the number of neighbors decreases and the bond length increases.
* The strongest PL signal is obtained by either annealing sample with 5% of Er by FA at 1100°C or by annealing sample with 1% of Er by RTP at 900°C.

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