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Influence of oxygen content on the 1.54 μm luminescenceof Er-doped amorphous SiO_x thin films

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content

Introduction

- Erbium has played an important role in the development of the optical communication technology because the $^4I_{13/2}$-$^4I_{15/2}$ transition in the internal 4f shell of the trivalent Er^{3+} ion presents an emissionat1.54 mm, which corresponds to the maximum transparency of the silica-based optical fiber.

- In order to better define the optimal material for the luminescence of the Er^{3+} ions in the near-infrared range, we have studied the influence of the oxygen content in amorphous SiO_x thin film son the Er-related luminescence.

- The films with different oxygen contents ($0 \leqq x \leqq 2$) were prepared by co-evaporation of Si and SiO_2 and were annealed at temperatures up to 900 ℃.

Experiment

- The films were prepared by co-evaporation of SiO powder from a thermal cell and of SiO_2 powder from an electron beam gun in a high-vacuum chamber with a base pressure equal to10^{-8} Torr.

- The prepared samples had the composition Si, $SiO_{0.4}$, $SiO_{0.8}$, $SiO_{1.0}$, $SiO_{1.2}$, $SiO_{1.6}$, and SiO_2.

- The thickness of the films was equal to 200 nm.
- The Er concentration was equal to 0.8 at%.
- The silicon substrates were maintained at 100 ℃.
- The structure of the films was analyzed by Fourier transform infrared (FTIR) spectroscopy.

- For the PL experiments, two different setups were used.

- For the setup 1, the excitation was obtained with the UV lines of a 200W mercury arc lamp source.
- detection range : 400–950nm

- For the setup 2, the samples were excited by the 325nm line of a 30mW He–Cd laser.
- detection range : 600–1700nm

Results and Discussion

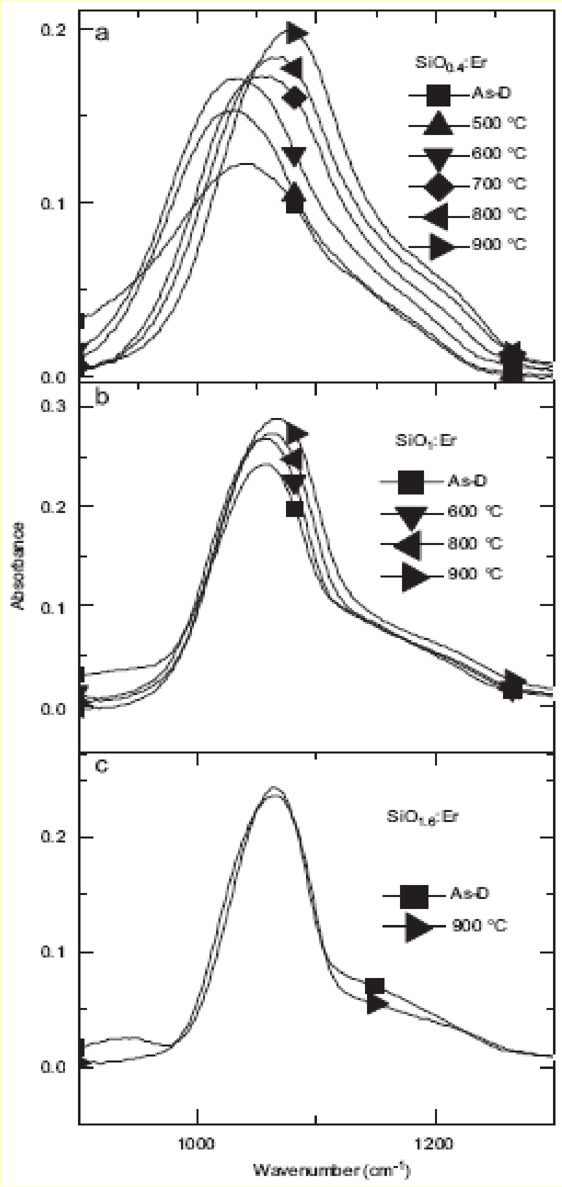


Fig.1(a):

- The as-deposited sample presents an infrared absorption band at 1045cm^{-1}.
- For a sample annealed at 400℃, this band shifts to 1030cm^{-1}.
- It finally reaches 1070cm^{-1} for Ta equal to 900℃, which corresponds almost to SiO_2.

Fig.1(b):

- For $SiO_{1.0}$ the structural change is clearly visible after an annealing treatment at 600℃.

Fig.1(c):

- The decomposition process is hardly visible at 900℃.

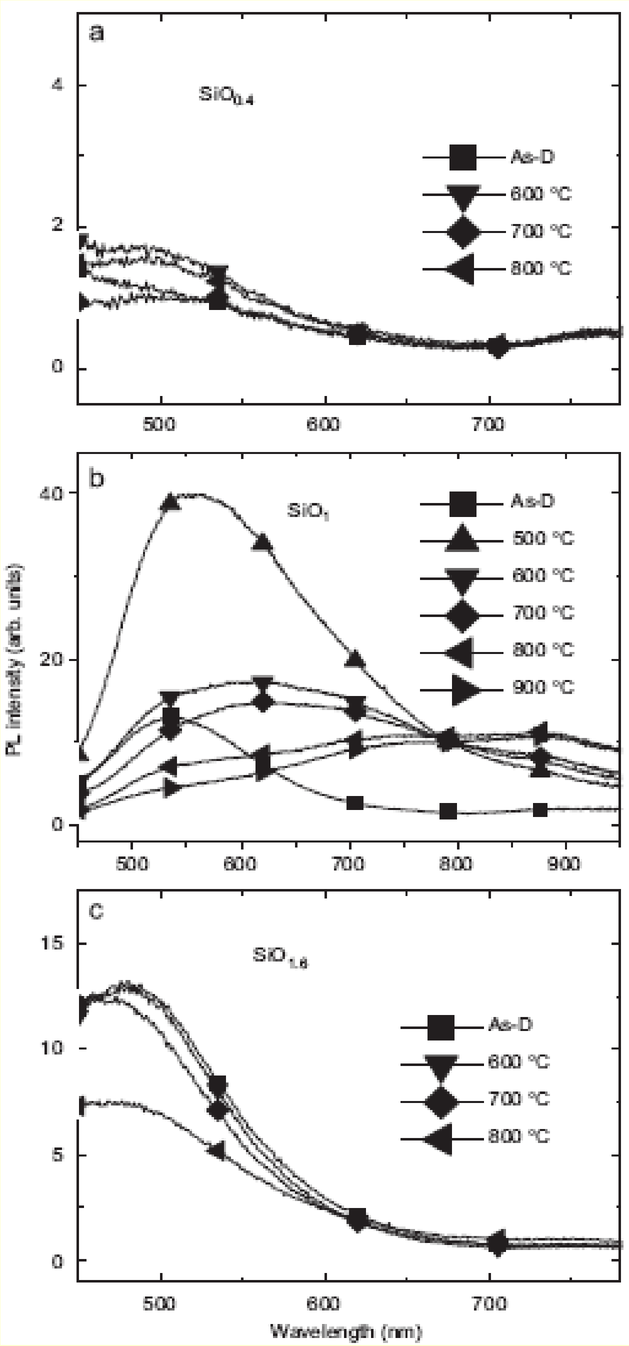


Fig.2(a):

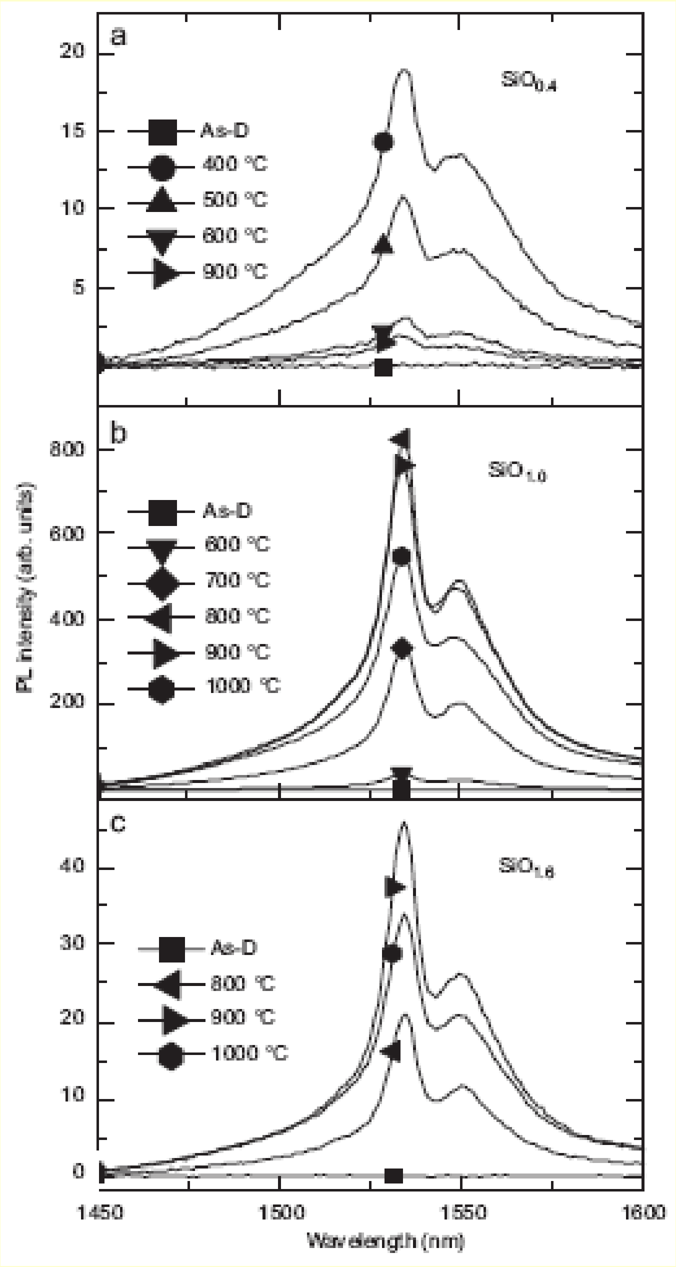
- The $SiO_{0.4}$ sample shows only a hardly visible band around 500nm.

Fig.2(b):

- The as-deposited sample presents a broad band at 550 nm.
- Its wavelength red shifts with annealing treatment at 800 and 900℃.

Fig.2(c):

- Only a band is observed at 500 nm.



- The band observed around1.54 mm is characteristic of the radiative emission from the $^4I_{13/2}$—$^4I_{15/2}$ transition of the Er^{3+} ions.

Conclusions

- SiO_x alloys($0 \leqq x \leqq 2$) have been prepared by co- evaporation of Si and SiO_2 onto substrates maintained at 100℃.

- For the low annealing temperatures, the PL spectra in the visible range show a band around 500nm which is attributed to defects in the oxide matrix.

- For annealing temperatures between 600 and 900℃, abroad PL band around 800nm is attributed to amorphous silicon aggregates which appear at these temperatures in the samples with $0.8 \leqq x \leqq 1.2$.

- For the same samples, an Er-related band is well visible at 1.54 μm.
- The strongest intensity is obtained for the $SiO_{1.0}$ sample annealed at 800 ℃.
- The high PL intensity can be attributed to an energy transfer from the amorphous silicon aggregates towards the Er^{3+} ions.

Thank you for your attention