



## **The 1.54- $\mu\text{m}$ photoluminescence from an (Er, Ge) co-doped $\text{SiO}_2$ film deposited on Si by rf magnetron sputtering**

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# Introduction

- $\text{Er}^{3+}$  luminescence at  $1.54 \mu\text{m}$ , due to the intra- $4f$  transition from the first excited to the ground state ( ${}^4I_{13/2} \rightarrow {}^4I_{15/2}$ ), has attracted great interest, since the emission wavelength is coincident with the absorption minimum of silica-based optical fibers.
- In this work, we report the PL property from an (Er, Ge) co-doped  $\text{SiO}_2$  structural sample deposited by rf magnetron sputtering, and the influence of the annealing conditions on the PL.

# Experiment

- film : (Er, Ge) co-doped SiO<sub>2</sub>
- substrate : n-type Si
- rf power : 200W
- chamber pressure :  $5 \times 10^{-7}$  torr
- annealing : 30min in N<sub>2</sub>; 700、900、1000、1100°C

- type A:

<b>(Er, Ge) co-doped SiO<sub>2</sub></b>
n-type Si

an Er+Ge+SiO<sub>2</sub> composite target

The area ratios of the metal Er, Ge plates, and SiO<sub>2</sub> matrix in the target was 1: 3.3: 95.7.

thickness : 1.1 μ m

- type B:

<b>Er doped SiO<sub>2</sub></b>
n-type Si

an Er+SiO<sub>2</sub> composite target

thickness : 730nm

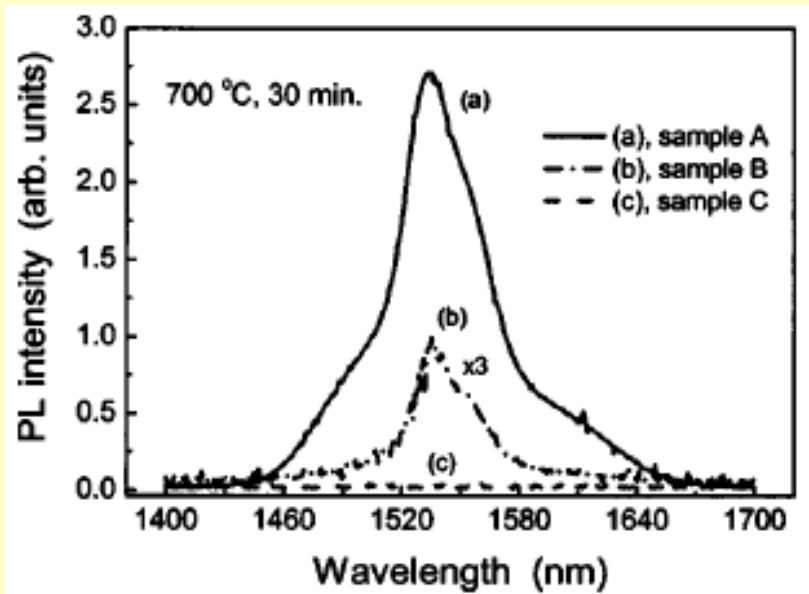
- type C:

<b>Ge doped SiO<sub>2</sub></b>
n-type Si

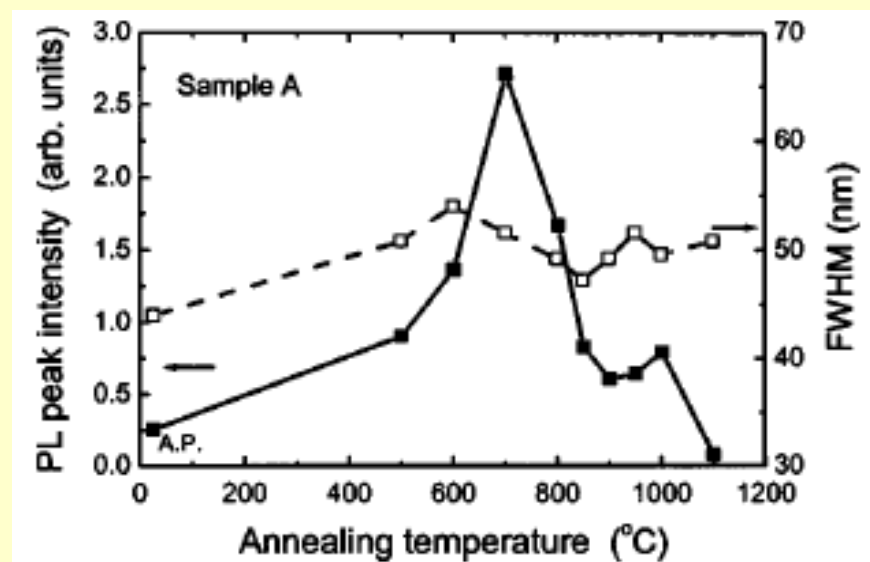
a Ge+SiO<sub>2</sub> composite target

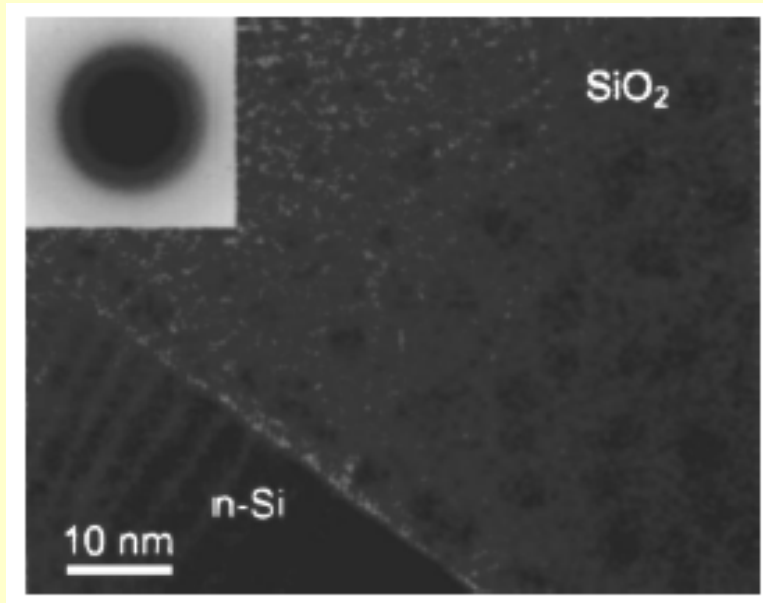
thickness : 550nm

# Results and Discussion



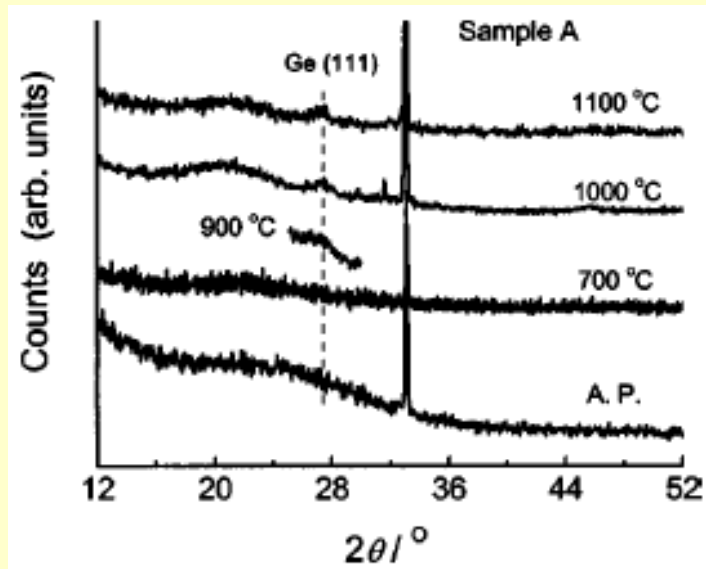
Ar laser : 488nm





Many dark dots with a size range from 2 to 6 nm are seen in the picture.





The sizes of nc-Ge are estimated from the width of the (111) peak to be on average 2.7 and 3.4 nm for the 1000 and 1100 °C annealing cases, respectively.

Scherrer formula :

$$D = 0.9 \lambda / \beta \cos \theta$$

D: 顆粒尺寸

$\lambda$  : 輻射波長 (Cu K  $\alpha$  為 0.154056 nm)

$\beta$  : 繞射峰的半高寬

$\theta$  : 繞射峰的角度

# Conclusions

- The PL intensity reaches its maximum after annealing the film at 700 °C for 30 min.
- Analysis of the experimental results indicates that the amorphous Ge or Ge-rich nanoclusters play a more effective role in exciting the Er<sup>3+</sup> luminescence than the nc-Ge.