Photoluminescence from erbium doped SiO_2 glass for a fluorescence thermometer application

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Erbium (Er) doped silica fibers, which is used in the fiber amplifier, are interested for temperature sensing materials in the fiber-optic fluorescence thermometer because their absorption and emission properties are highly sensitive to temperature. Er doped silica fibers (Er fiber) have, therefore, been widely used for the study of the fiber-optic thermometer at around room temperature. However, present Er fiber used in the fiber amplifier is not suitable for the high temperature measurement in such as silicon (Si) device fabrication process in which operation temperature is about 1273 K. In the Er fiber, doped impurities such as sodium (Na) and germanium (Ge) decreases the upper temperature limit of measurement and contaminate to Si wafers. In order to develop the Er doped quartz sensor head (Er sensor head) for the fiber-optic thermometer at high temperature, fabrication process of Er sensor head must be improved with optimum condition. In this paper, optimum density of Er and aluminum (Al), which doped in quartz glasses, is reported in detail.

In the modified fabrication condition, specimens were prepared from 4N-quartz, 4N-alumina and 4N-erbium oxide powders. Erbium oxide with the concentration form 100 ppm to 20000 ppm were mixed into the quartz powder. Aluminum oxide were also mixed into Er doped quartz powder. The amount of Al was varied from 0 to 50 times larger than the amount of Er. Powders were subsequently sintered at 1423 K for 3h in air. Powders were mixed with 5 % poly-vinyl alcohol (PVA) aqueous solution. The quartz rod (1.5 mm in diameter, 150 mm in length) were dipped into the slurry of Er doped quartz powder, then dried in Air. Droplet of dried Er doped quartz slurry was melted using LPG-O_2 gas flame. Small spherical Er sensor head within 3 mm diameter have been directly connected on the quartz rod. The photoluminescence spectra of the sensor head were measured using the laser diode, LD, (980 nm, 50 mW) as an excitation light source. The PL peaking at 1535 nm were observed using liquid nitrogen cooled Ge photodetector in each Er sensor heads. The peak PL intensity from the Er sensor heads increases with increasing Er concentration up to 5000 ppm. The peak PL intensity from the Er sensor heads increases with an increase of Al content up to the weight ratio of Al/Er=15 as well as Er density. From these results, the Er doped quartz sensor head with Er density above 5000 ppm and above Al/Er=15 is considered to be suitable for the fiber-optic thermometer. The temperature dependence of PL lifetime from Er doped quartz sensor head have also been evaluated at the temperature range over 273 K to 473 K. The PL lifetimes of the Er sensor head decreases from 15 ms to 10 ms with temperature from 273 K of 473 K. Er sensor head is, therefore, considered to be potentially useful for temperature measurement of Si process.

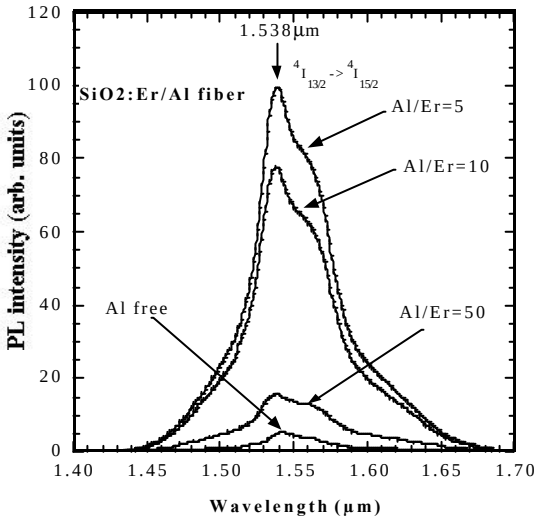

Fig. 1. PL spectra from Er doped SiO2 glass. Peak intensity varies with Al concentration.