Effect of graphene on photoluminescence properties of graphene/Er-doped ZnO thin film hybrid structure

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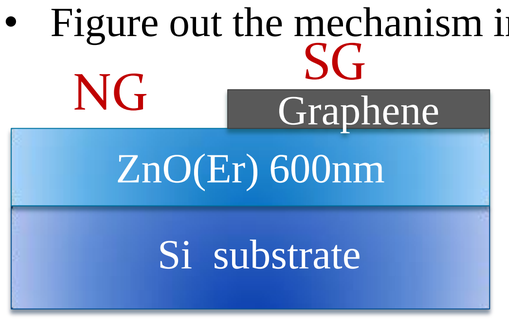
Introduction

Due to the great progress of optical communication systems, the low-loss wavelength region of 1400-1700 nm plays an important role in a silicon-based optical fiber. Er-doped ZnO thin film can achieve the emission of 1533 nm wavelength light from Er^{3+} ions, so it is vital significant to research this material and improve the PL intensity. In our experiments, we use the excellent plasmonic characteristic of graphene to realize the enhancement of PL intensity of Er-doped ZnO thin film.

Motivation

- Enhance the photoluminescence of Er-doped ZnO film.
- Figure out the mechanism in the hybrid structures



NG: the region of this material without graphene
SG: the region of this material with graphene

Experiments

Methods of the experiments:

- Er-doped ZnO film produced by magnetron sputtering, annealed at 950◦C for 30 min.
- Graphene produced by CVD.

Measurement method:

- We used 325 nm and 488 nm wavelength laser to irradiate the sample at different region (SG and NG) .

Results

325 nm laser

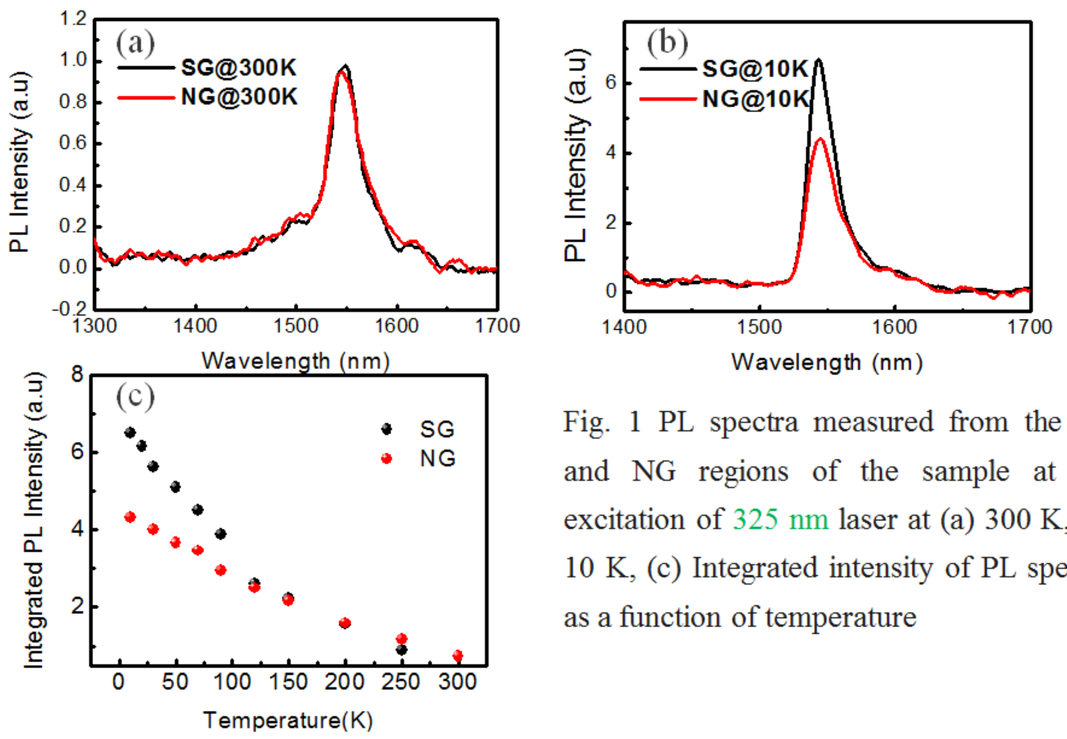


Fig. 1 PL spectra measured from the SG and NG regions of the sample at the excitation of 325 nm laser at (a) 300 K, (b) 10 K, (c) Integrated intensity of PL spectra as a function of temperature

At the excitaton of 325 nm laser, the PL intensity from the SG region is about 1.8 times stronger than that from the NG region at 10 K. As the temperature increases, the enhancement is more and more inconspicuous, and at 300 K there is no enhancement.

488 nm laser

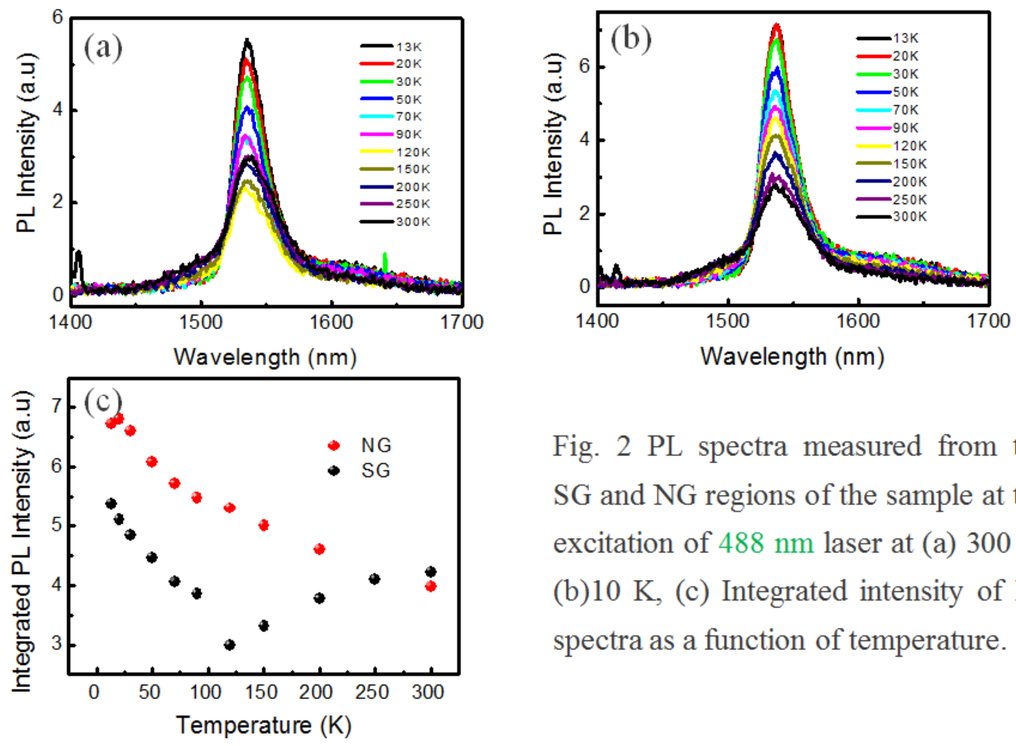


Fig. 2 PL spectra measured from the SG and NG regions of the sample at the excitation of 488 nm laser at (a) 300 K, (b)10 K, (c) Integrated intensity of PL spectra as a function of temperature.

At the excitaton of 488 nm laser, the hybrid structure had a reduced PL intensity at 10 K. As the temperature increases, the attenuation is increased from 10 K to 120 K, and then decreased. At 300 K, there is less enhancement at SG region.

Conclusion

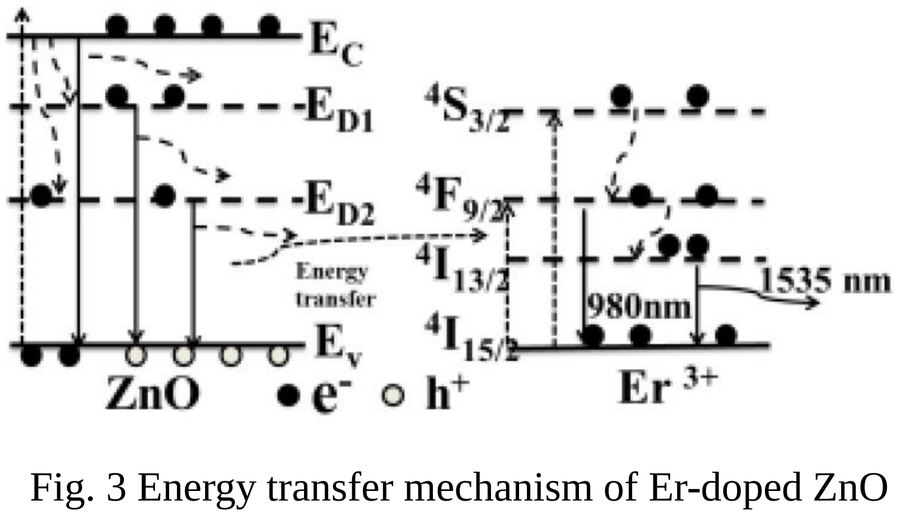
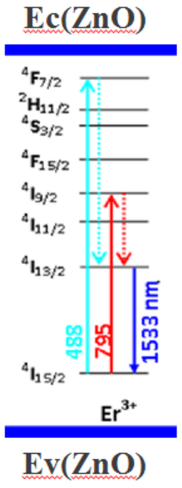


Fig. 3 Energy transfer mechanism of Er-doped ZnO film inspired by 325 nm laser

- **325 nm（ indirect excitation ）**
  1) absorption of excitation energy by ZnO.

SPP effect of graphene enhances the absorption.

  2) energy transfer from ZnO to Er ions.
  3) radiative relaxation inside Er



- **488 nm（direct excitation）**
  1) absorption of excitation energy by Er^{3+},
  2) radiative relaxation inside Er

Electron or Energy transfer mechanism, which leads to the attenuation in PL intensity.

Fig. 4 Energy transfer mechanism of Er-doped ZnO film inspired by 488 nm laser

Next step

Fabricating a space layer between graphene and Er-doped ZnO thin film to further study the interaction of them.