Effect of background gas and substrate temperature on ZnO:Zn PLD thin films

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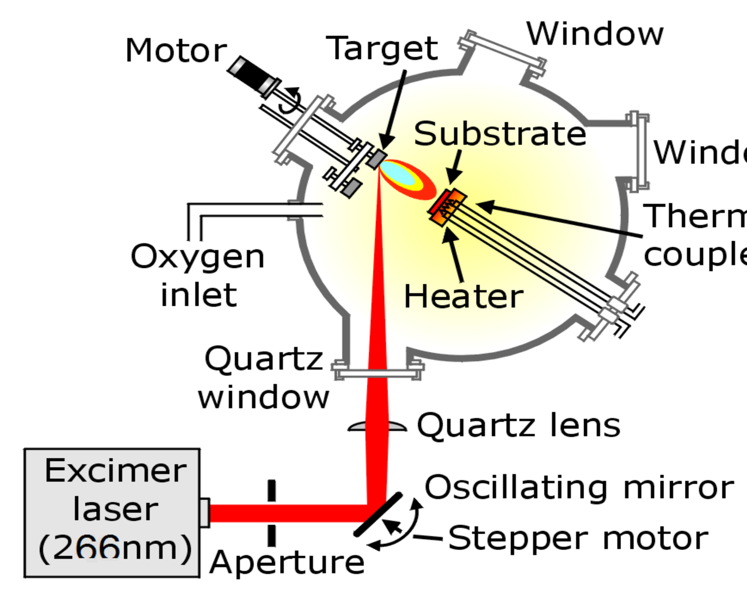
1. Introduction

ZnO has attracted considerable attention as a low-cost, environmentally-friendly photonic material due to its direct bandgap (3.37 eV at room temperature) and a large exciton binding energy (60 meV)[1,2]. ZnO doped with some impurities (e.g., Zn) to enhance or modify its physical properties become quite essential for lighting applications. In the present work Zn doped ZnO thin films have been deposited by Pulsed Laser Deposition (PLD) under different atmospheres and different substrate temperatures. The obtained results showed that the changes in these parameters have significant affects on the physical properties of the ZnO:Zn thin films. The photoluminescence (PL) properties from the thin films could be controlled by the substrate temperature and background gas. The PL showed that the emission from the ZnO:Zn thin films was defects related. These results suggested that the ZnO:Zn thin films may be useful in lighting applications.

2. Experimental

A commercial ZnO:Zn powder, was ablated on Si (111) substrates by using a 266 nm Nd:YAG pulsed laser. The deposition was carried out in different atmospheres (oxygen, argon and vacuum) and different substrate temperatures (50, 200, 300 and 400°C) for the thin films deposited in an oxygen atmosphere.



Schematic diagram of Pulsed Laser Deposition system

3. Results

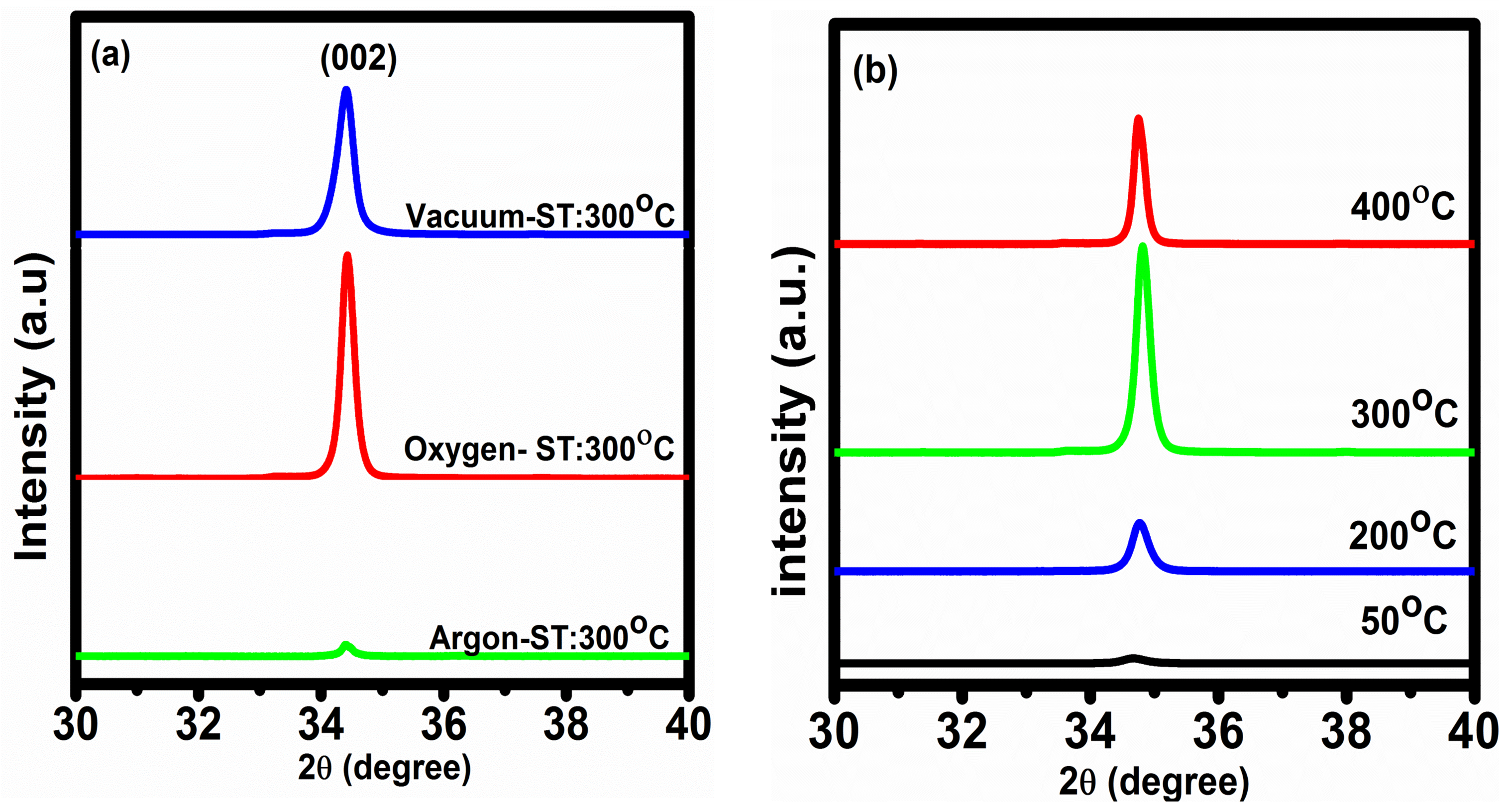


Figure 1. X-ray diffraction (XRD) patterns of ZnO:Zn thin films deposited in (a) different growth atmospheres and (b) at different substrate temperatures.

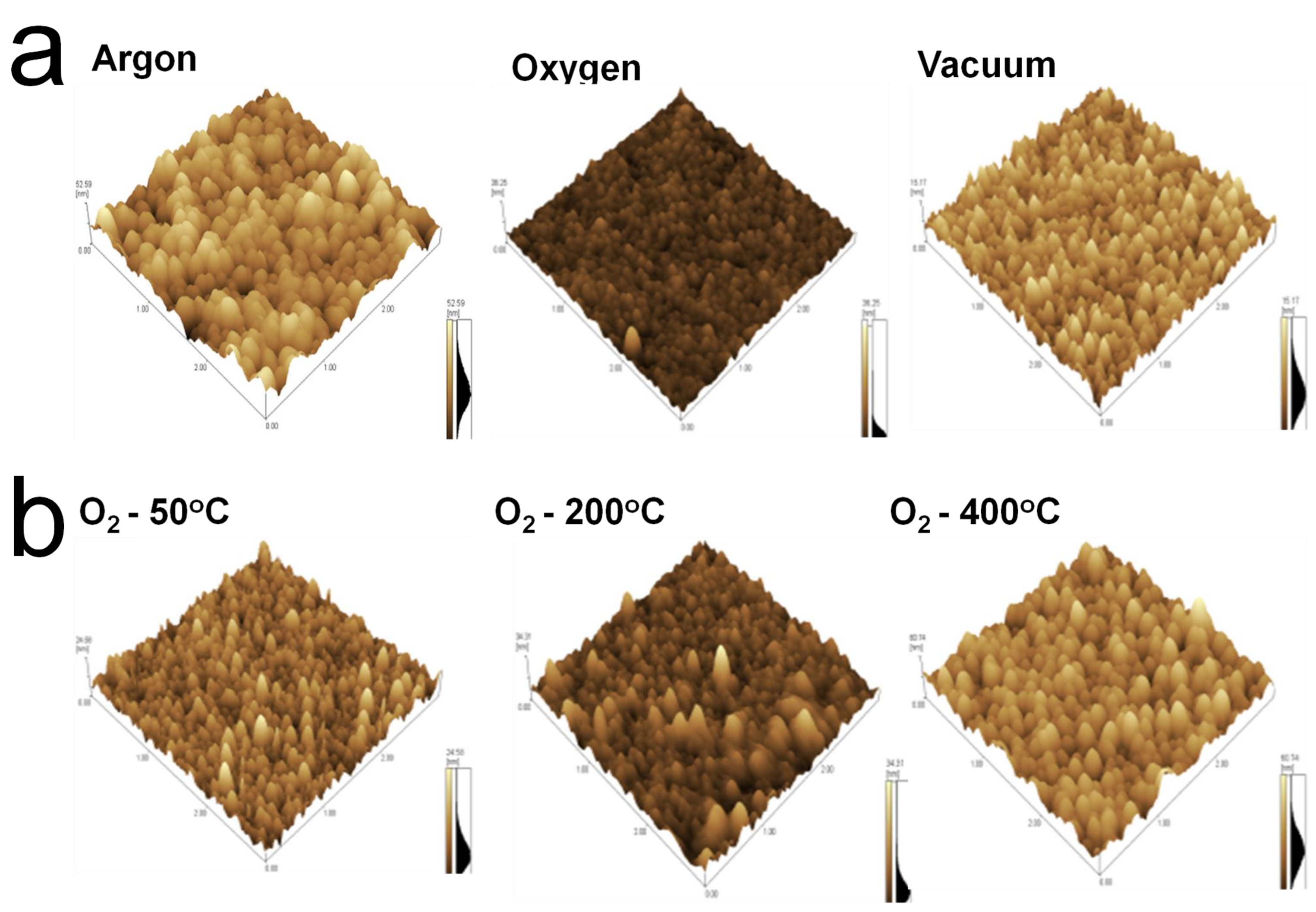


Figure 2. Atomic Force Microscopy (AFM) images of ZnO:Zn thin films deposited (a) in different growth atmospheres (b) at different substrate temperatures for the oxygen background gas .

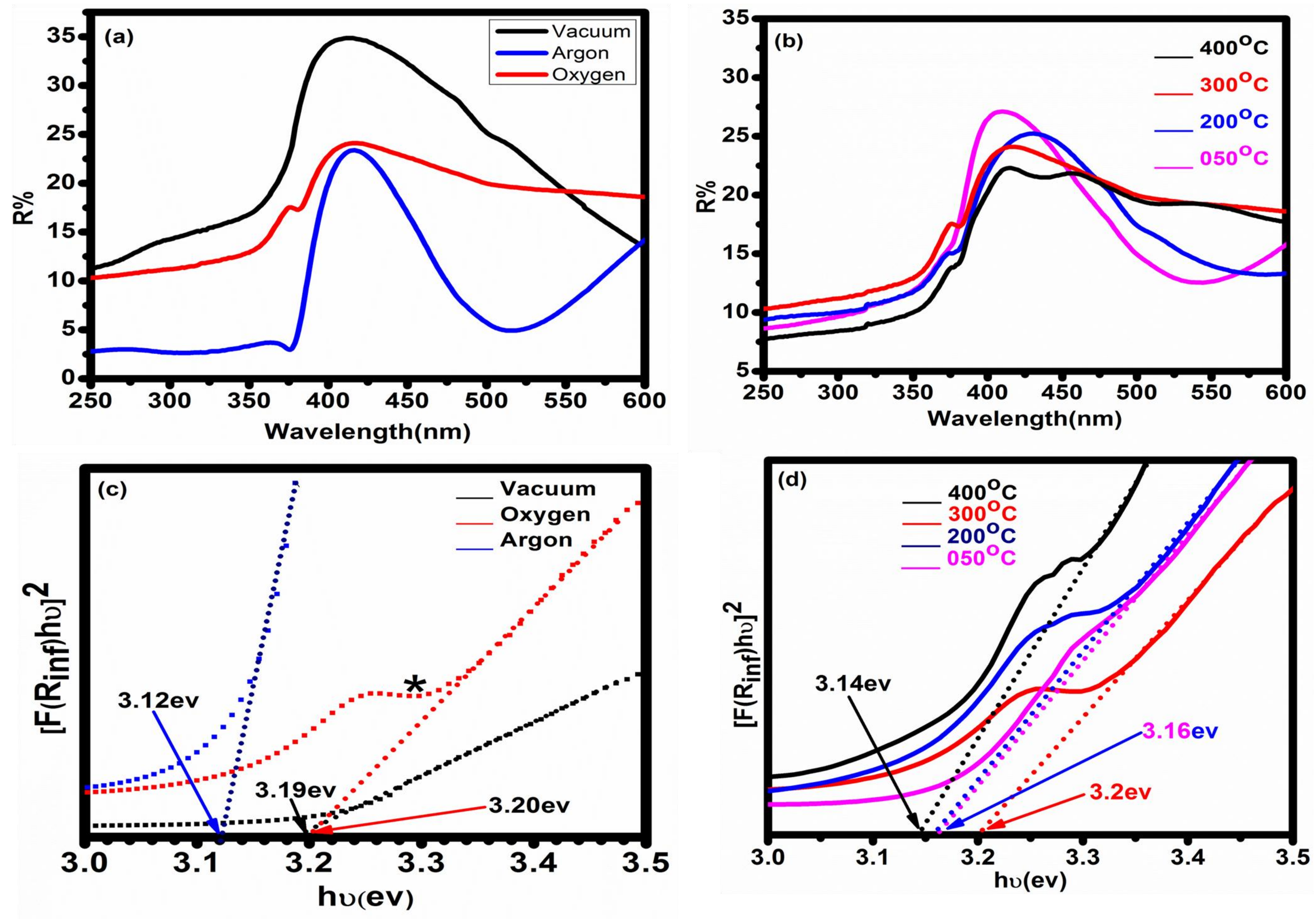


Figure 3. Diffuse reflectance of the ZnO:Zn thin films (a) in different growth atmospheres (b) at different substrate temperatures. (c and d) is the graphs for the calculation of the band gap of the ZnO:Zn thin films for the samples in (a) and (b) respectively.

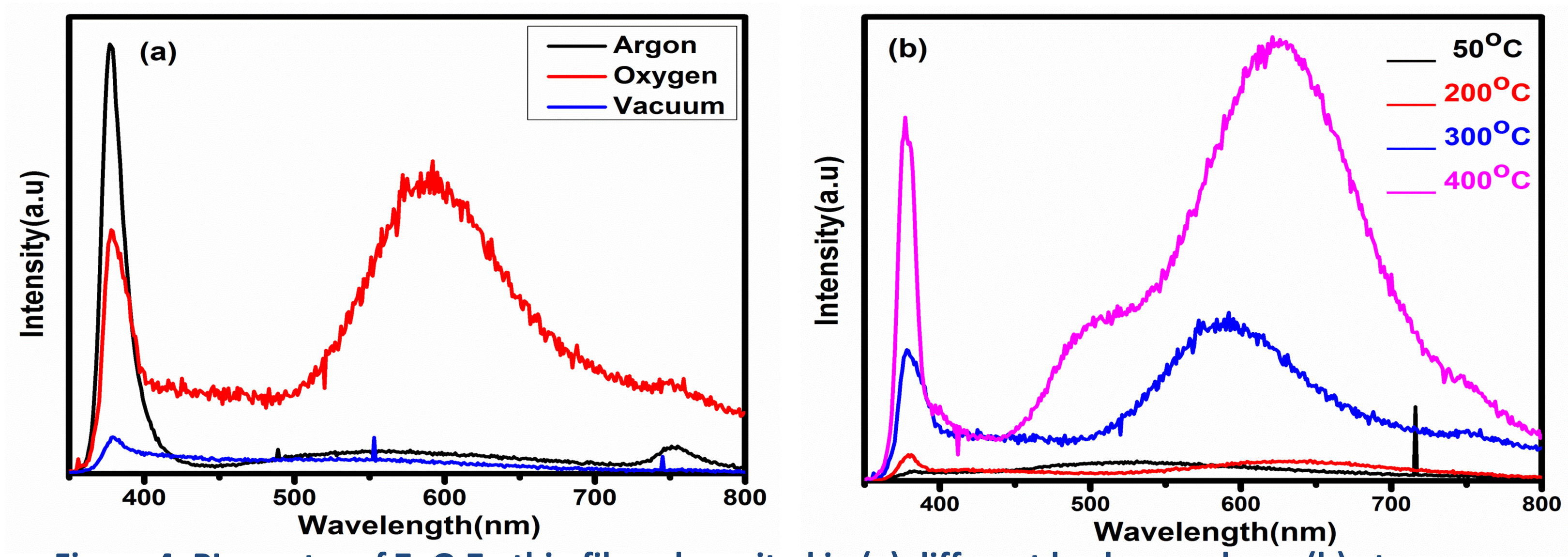


Figure 4. PL spectra of ZnO:Zn thin films deposited in (a) different background gas, (b) at different substrate temperatures.

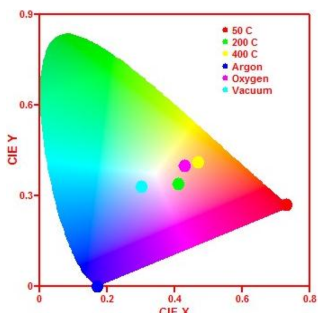


Figure 5. CIE diagram of ZnO:Zn thin films deposited in different background gas and at different substrate temperatures.

4. Conclusion

ZnO:Zn thin films were deposited on Si (111) substrates in different growth atmospheres and different substrate temperatures by the PLD technique. XRD confirmed the formation of highly crystalline hexagonal wurtzite structure of ZnO oriented on the C-axis. AFM results showed that the substrate temperature and the background gas have significant affects on the growth of the particles size. The PL results showed that the emission related defects can be manipulated by changing the substrate temperature. Near white light was observed when the substrate temperature was 400°C.

5. References

[1] Kumar V, Swart H C, Som S, Kumar V, Yousif A, Pandey A, Shaat S K and Ntwaeaborwa O M, 2014 *Laser Phys*. 24: 105704
[2] Janotti A and Van de Walle, C G, 2009 *Rep. Prog. Phys*. 72: 126501

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