PFCVAD GROWN n and p-TYPE ZnO THIN FILMS FOR DEVICE APPLICATIONS

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Zinc oxide (ZnO) is an attractive material for thin-film electronics due to its wide bandgap, good electrical transport, and transparency. For the development of optoelectronic devices with ZnO, it is necessary to have high quality materials of both n-type and p-type. However, polycrystalline ZnO is naturally n-type and very difficult to dope to make p-type. Therefore nowadays hardly produced p-type ZnO attracts a lot attention. Nitrogen considered as the best dopant for p-type ZnO thin films[1,2].

Pulsed Filtered Cathodic Vacuum Arc Deposition (PFCVAD) method was used to deposit n and p-type ZnO thin films. The structural properties such as, interplaner distances, grain size and orientation were calculated using XRD data. The transmission and absorption spectra were taken to calculate optical energy band gap, absorbance band edge, band tailing and refractive index and film thickness. The electrical properties such as resistivity, mobility, carrier concentration and type were determined.

Two different techniques had been used to produce p-type ZnO thin films. Firstly zinc nitride compound was deposited and annealed at different temperatures to convert it into p-type ZnO by thermal oxidation. Second technique for producing p-type ZnO thin films is directly doping with different nitrogen concentrations.

For oxidation zinc nitride, the sample was annealed in air starting from 350 ºC up to 550 ºC for one hour duration[3]. XRD pattern of these films have diffraction peaks with (100), (101) and (110) orientations. These XRD patterns imply that zinc nitride thin films converted to zinc oxide thin films with the same hexagonal crystalline structures of ZnO. In the case of directly N doped p-type ZnO thin films, the high purity oxygen and nitrogen gases were given during the deposition with different ratios. The optical transmissions of n and p-type ZnO thin films were over 90% in visible range after annealing over 350 ºC. Hall effect measurements indicated that ZnO films were p-type and the highest carrier concentration of 2.39×10^{18} cm^{-3} and mobility of 63.98 cm^2/Vs. Hall effect measurements proved that after annealing at 350 ºC up to 500 ºC the film was p-type, however when oxidation temperature was over 550 ºC the ZnO thin films turned into n-type due to the lack of N atoms in the film[4].

The deposited best quality n and p type ZnO thin films were used to produce hetero and homo-junctions. P-type ZnO deposited on the n-type Si substrate and indium was evaporated as metal contacts (n-p). On the other hand n-type ZnO deposited on p-type Si substrate for p-n structure[5]. Current-Voltage characteristics of these devices were determined and the typical result for p-n hetero-junction was shown in the Figure.

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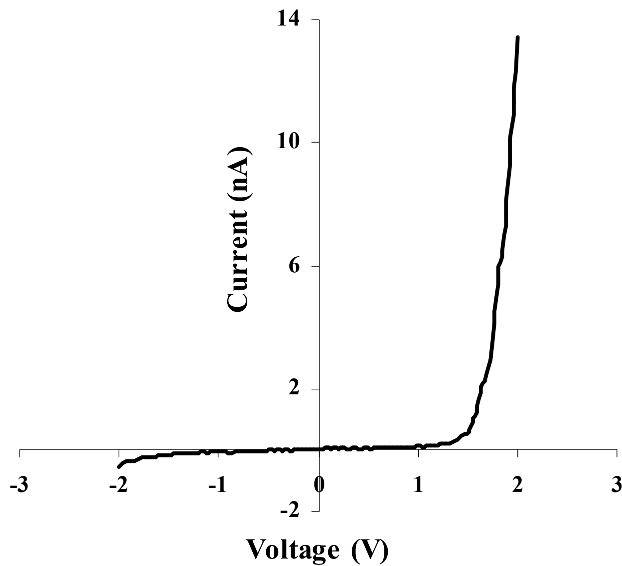

Figure. The Output Characteristics of p-n junction