Ar itriju dopētas ZnO plānās kārtiņas un daudzslāņu struktūras
(Yttrium doped ZnO thin flms and multilayers)

Project No: SJZ/2018/12
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In the scope of the project;

A- Deposition of the Y- Y_2O_3, ZnO, ZnO:Y and multi-layer ZnO/YO/ZnO thin films, by varying parameters such as temperature, pressure and substrate material, was done by means of the DC magnetron sputtering vacuum cluster tool SAF 25 and DC magnetron sputtering located in the Thin film laboratory.

B- Characterization of the structure (s); Following techniques were carried out.

1- Profilometer
2- X-Ray fluorescence (XRF)
3- UV-VIS Spectroscopy
4- Spectroscopic Ellipsometer
5- Hall effect measurement
6- X-Ray diffraction (XRD)

Transparent electrodes are primary components for optoelectronic devices, such as touch panels, organic light-emitting diodes, and solar cells. Indium tin oxide (ITO) is widely used as a transparent electrode in optoelectronic devices (For instance, it is necessary for hole collection / injection in organic photovoltaic cells and organic light emitting devices). Even though ITO has high transparency and low resistance it is toxic and expensive, and the price could increase even more if In consumption continues to increase. Moreover, ITO exhibits low mechanical flexibility and an elevated deposition temperature (> 300 ^{O}C) is necessary to obtain desired properties. The sheet resistance of polycrystalline ITO may significantly increase with cyclic bending beyond a low bending radius due to the cracks that reduce the quality of the electrochromic (EC) devices. The high deposition temperature forbids the use of polymer substrates for the flexible EC devices. Therefore, **alternative transparent electrodes** with excellent opto-electrical performance and mechanical flexibility will be greatly demanded and are currently under development (See table 1), such as less expensive dielectric/metal/dielectric (DMD) multilayer electrodes. **ZnS/Ag/ZnS** , **MoO_3/Al /Cu /WO_3** ,**WO_3/Ag/ WO_3**, **MoO_3/Ag/MoO_3** , **ZnO/Ag/ZnO** are the most conventional DMD structures. In addition to the above mentioned there is a great interest in metal/dielectric (M/D) superlattices for magneto-optic recordings (Atkinson Ron, UK, 1993) for more than two decades, that emphasize the importance of the dielectric-metal combination in the related technology. On the other hand ZnO:R (Al,Ga) is commonly used TCO material. In this project we propose to dope **ZnO** with **Y** besides multilayers **ZnO/YO/ZnO** and producing **Y-Y_2O_3** thinfim**.**

Table 1. The comparison of different transparent electrodes.

Transparent Electrodes	Advantages	Disadvantages
ITO	- High Transmittance (> % 90) - Low sheet resistance (< 20 ohm/sq.)	- Poor mecahnical flexibility - High deposition temperature (> 300 ^{o}C) - Increasing cost of Indium
Carbon nanotube	- Good mechanical flexibility - Low material cost	- Low transparency (~ % 75) - High sheet resistance (10^2-10^3 ohm/sq.) - Rough surface - Poor uniformity
Graphene	- Good mechanical flexibility	- High sheet resistance (10^2-10^4 ohm/sq.)
Metal nanowires	- High transmittance (> %80) - Low sheet resistance (10-10^2 ohm/sq.) - Good mechanical flexibility	- Rough surface - Poor enviromental stability
Dieletric/ Melal/ Dielectric (DMD)	- High tranmittance (> %80) - Low sheet resistance (<15 ohm/sq.) - Good mechanical flexibility	- Multi deposition - Narrow emission width by strong microcavity effect

Results reveal that albeit the doping rate of Y (up to 7.6%) in ZnO structure can alter the optical (See the figure 1) properties of the film it does not, remarkably, affect the electrical feature, which tends to stay in insulating phase, of the thinfilm.

This optical transmission, ~ %80, of the YZO thin film in the visible range of the spectrum covers the expectations for transparent electrodes. In addition to this the doping rate of Y (over 6 %) triggers the crystallinity (nano crystallinity starts) of the ZnO.

On the other hand temperature and substrate dependency of the formation of Y-Y_2O_3-YO_2 structures may catch the attention (see the figure 2)

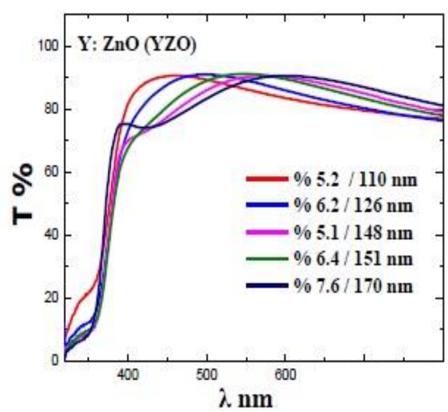

Figure-1 Optical transmission of ZnO

This behavior of the material can be assumed as either advantage or disadvantage depending on the desired application.

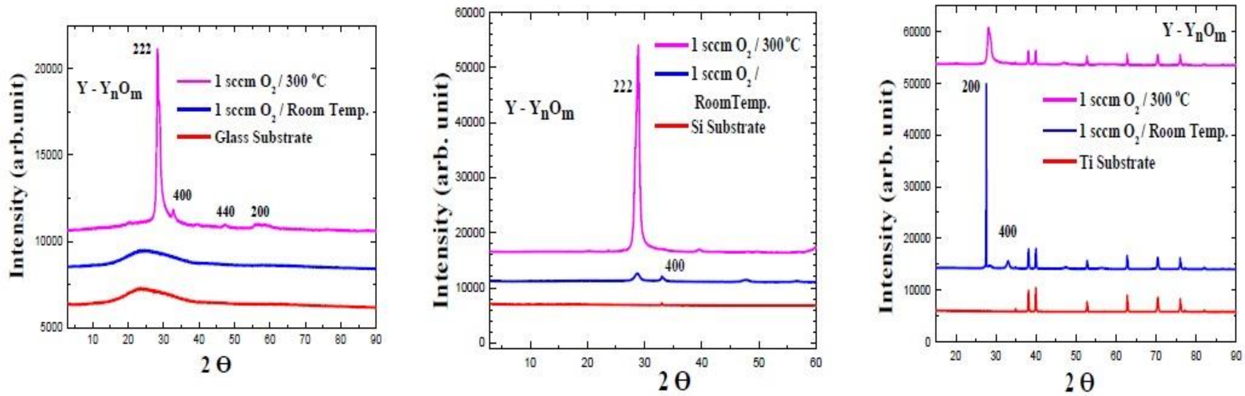

Figure -2 Temperature and Substrate dependency of Y_nO_m thinfilm

As a second conclusion one can understand the importance of the of the O_2 inlet position has a direct effect on the formation of Y- O crystal structure see the figure 3. Depending on the inlet position both it is possible to increase the crystallinity, which may contribute the electrical conductivity, of a single phase and creating a different stoichiometry. In order to understand the influence of the temperature on the multi structure systems we heated the substrate at round the melting point on Zn. In this experiment it was targeted creating metallic Y or YO_x so that to increase the electrical conductivity of the structure as balancing the optical transmission in the visible range (Notice the figure below).

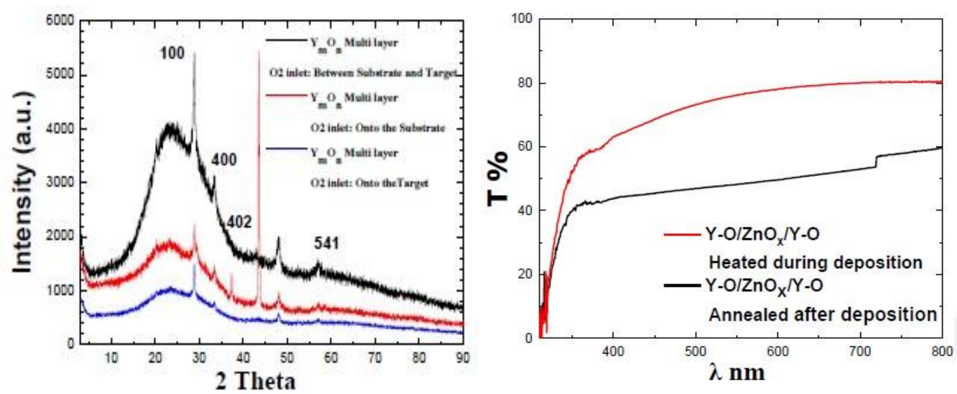

Figure -3 The effect O_2 Inlet position on the structure (left), Optical transmission of multilayers (right)