Electrical Parameters of the Ag/MoO_x/CdSe QDs/ZnO QDs/ITO Structure Based Photodiodes

In Fig 2.6 of Chapter 2, we have already discussed the current density-voltage (J-V) characteristics under dark and illuminated conditions of three Ag/MoO_x/CdSe QDs/ZnO QDs/ITO structure based diodes A, B, and C using ZnO QDs films annealed at three different temperatures 250°C, 350°C, and 450°C respectively. A white LED light source with spectrum shown in Figure A.1 is used for investigating the optical characteristics of A, B, and C as well as other devices considered in the entire thesis.

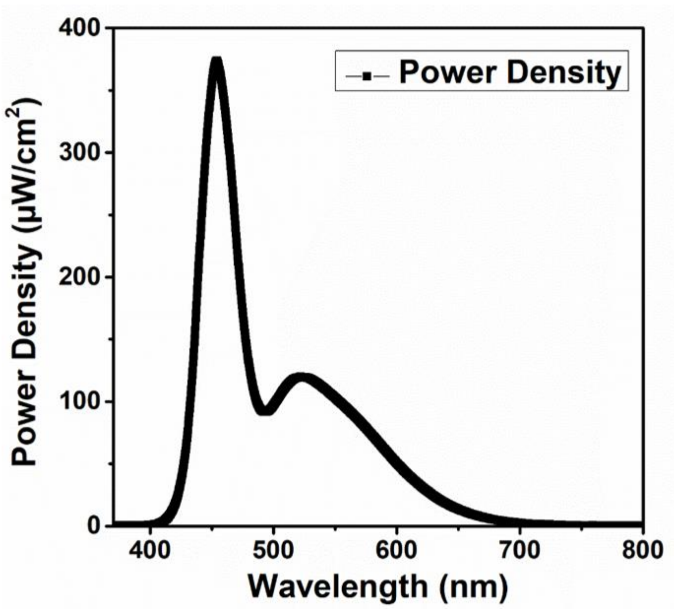

Figure A. 1: Spectrum of white LED light used for device illumination

The ZnO QDs are annealed at 250°C, 350°C, and 450°C to improve the crystalinity and the morphology of the deposited thin films (E Kymakis *et al.*, 2006). The increased size of ZnO QDs with annealing temperature improves the crystinality of the QDs and also modifies the interface which, in term, may lead to the slight shift of zero current (Yadav, Pandey and Jit, 2014) as shown in Figure 2.6. The room temperature forward current *(I)*, barrier height *($\phi_{B,eff}$)* and ideality factor *(η_i)* of the photodetectors A, B, C under study can be calculated under the dark condition by using the equations 6.1, 6.2, and 6.3 (Sze, 2002):

$$I = I_O\left\{= AA^*T^2 \exp\left(-\frac{q\phi_{B,eff}}{kT}\right)\right\}\exp\left(\frac{qV}{\eta_i kT}\right) \qquad (6.1)$$

$$\phi_{B,eff} = -\frac{kT}{q}\ln\left(\frac{I_0}{AA^*T^2}\right) \qquad (6.2)$$

$$n_i = \frac{q}{kT}\frac{dV}{d\ln(I)} \qquad (6.3)$$

where A is the contact area (0.075 cm^2), q is an electronic charge, V is the applied bias, I_0 is the reverse saturation current, T is temperature, k is the Boltzmann constant, and A^* is the effective Richardson constant (15.6 $Acm^{-2}K^{-2}$ for CdSe) (Tripathi, 2010). The values of reverse stauration current *(I_0)*, barrier height *($\phi_{B,eff}$)* and the ideality factor are shown in Table A.1.

Table A. 1: Comparison among the Device A, B and C at room temperature

Entities	**Device A**	**Device B**	**Device C**
Reverse saturation current (A)	1.20×10^{-8}	8.13×10^{-8}	2.42×10^{-7}
Barrier height ($\phi_{B,eff}$, eV)	0.77	0.72	0.69
Ideality factor, η_i	3.955	3.79	2.50

The results shown in Table A.1 shows that device “C” has the smallest ideality factor while “A” has the largest ideality factor. Thus, the device “A” has the poorest junction interface characteristics among the three devices. However, the device “A” has the lowest dark current and largest barrier height among the three diode structures under study. Since the lowest reverse saturation current represents the lowest dark current of the “A” photodetector, we have observed the best photoresponse characteristics of “A” device despite of its worst junction characteristics (i.e. largest ideality of factor) among the three devices under study in Chapter 2.