High reflective anode for top emission OLED

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Abstract

We present high reflective anode for top emission OLED. Anode consists of two layers, which are increasing the ability of hole injection and the reflectivity of emitted light.
Thin Cr is deposited on AlNd that has a high thermal resistance and reflectivity. The current-voltage characteristics of Cr(30Å)/AlNd(1000Å) anode are poor but these of Cr(50Å)/AlNd(1000Å) anode are superior to these of Cr(30Å)/AlNd(1000Å) and the work function of Cr(50Å)/AlNd(1000Å) is higher that of Cr(30Å)/AlNd(1000Å).

1. Introduction

Active matrix organic light-emitting diode (AMOLED has attracted much attention in recent years due to their good characteristics in display, for example no back-light, free view angle, high color purity, low power consumption and possibility of large size. There are two types of backplane for AMOLED. One is poly silicon TFT, the other is a-Si:H TFT. Compensated circuit should be designed to increase uniformity of brightness within display due to non uniform characteristic of ELA(Excimer Laser annealing) poly silicon TFT. TFT size must be large to increase drain current of a-Si:H TFT due to low mobility[1],[2],[3]. So aperture ratio of AMOLED has been low. That is the reason why top emission structure has been demanded in AMOLED[4]. ITO and thin Al have been used for transparent cathode and metals having high work function, for example Pd(5.0eV), Fe(4.5eV), Ni(5.2eV), Cu(4.6eV), Au,(5.1eV) and Cr(4.7eV) were used for reflective anode. But the metal materials that were guaranteed in LCD process were Al, AlNd, Mo, Cu and Cr. So Cr metals were selected as anode material. Because of low reflectance of Cr, we have developed Cr/reflector(AlNd) double layer as reflective anode. We have studied characteristics of Cr, Cr/AlNd reflective anode and optimized thickness of Cr layer on AlNd and condition of plasma treatment.

2. Experiment

Cr/AlNd, Cr were used for reflective anode. Organic and metal cathode was deposited on Cr/AlNd or Cr anode. Before loaded into the deposition chamber, glass substrate was cleaned by DI water. After cleaning, glass substrate was transferred to sputter system. AlNd was deposited on that substrate and patterned by photolithography and etch process. And then Cr was deposited and patterned by same process.

The substrates deposited Cr/AlNd, Cr anode were cleaned in acetone, IPA, DI water. After that, the substrates were dried 200°C for 1hr. Reflective anode fabricated were loaded to plasma treatment chamber and performed by plasma treatment.

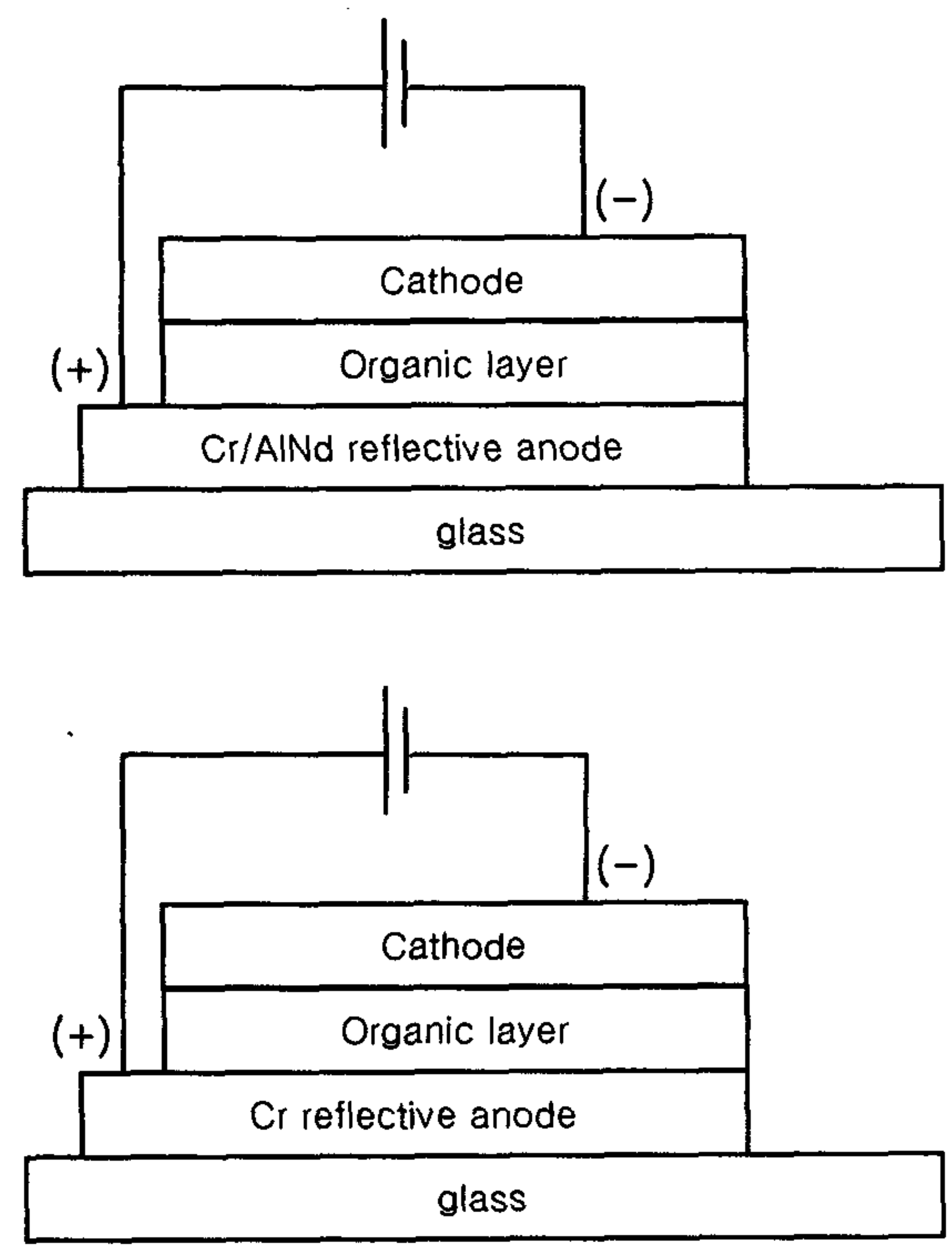

Figure 1. Structure of OLED using Cr/AlNd, Cr anode

Figure 1 shows the structure of OLED which was used in this work. The substrate that had Cr/AlNd or Cr anode was treated by Ar plasma and deposited organic or metal.

3. Results and discussion

3.1 Reflectance of Cr/AlNd anode

Figure 2 shows equipment of reflectance. Table1 shows each average reflectance of Cr/AlNd , Cr anode at incident angle(10°,15°,20°,30° and 45°). Source beam having incident angle (10°,15°,20°,30° and 45°) was reflected on Cr/AlNd anode and detected intensity of reflected.

Anode	Reflectance[%]
AlNd(1000Å)	100.0
Cr(1000Å)	49.41
Cr(50Å)/AlNd(1000Å)	63.26
Cr(30Å)/AlNd(1000Å)	77.95

Table 1. Reflectance of Cr/AlNd anode

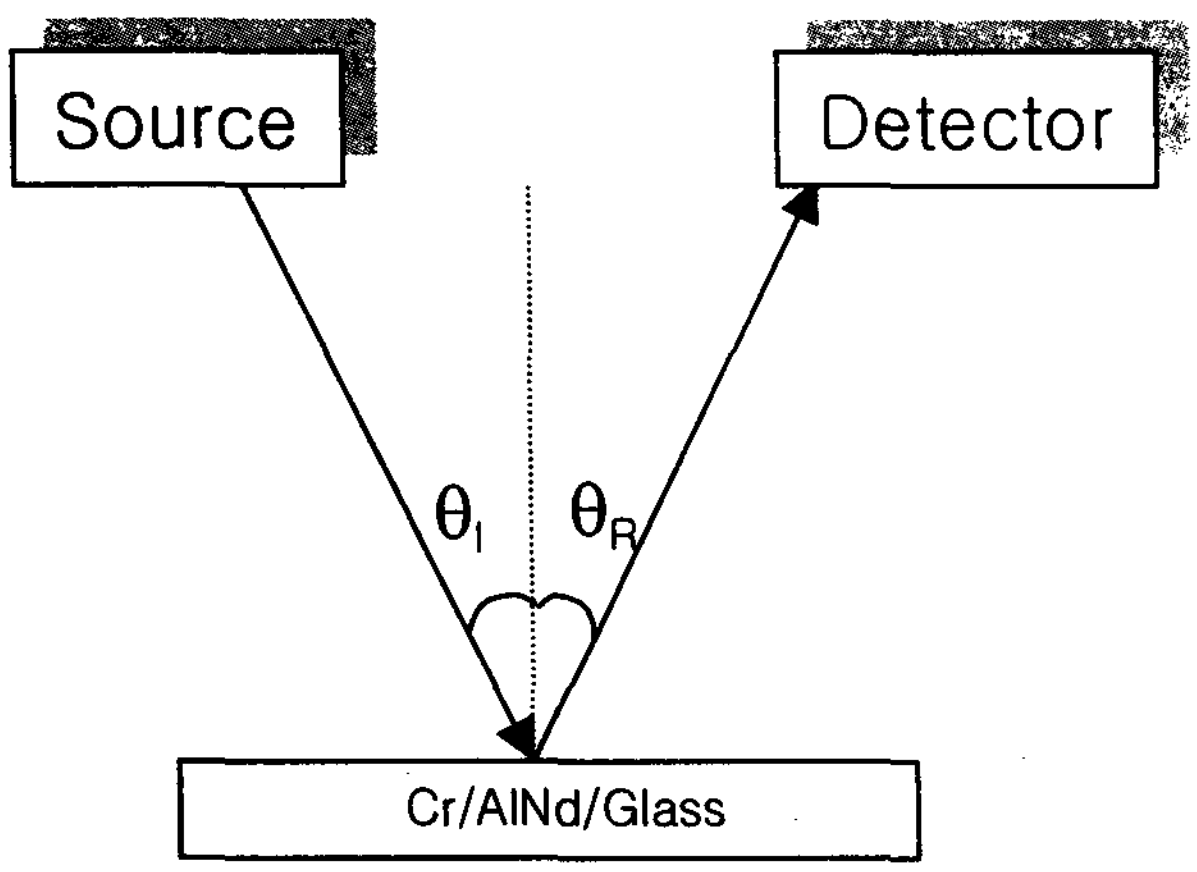

Figure 2. Measurement condition of reflectance

According to the Table1, the reflectance of Cr(30Å)/AlNd(1000Å) was higher than that of Cr(50Å)/AlNd(1000Å). This results reveal that reflectance of Cr/AlNd has relation to Cr thickness on AlNd reflector. Reflective source was transited through thin Cr layer and reflected on AlNd surface. Figure 3 shows that reflectance was varied by incident angle(θ_I). Average reflectance of Cr(30Å)/AlNd (1000Å), Cr(50Å)/AlNd(1000Å) was 78%, 63% respectively but Cr(1000Å) was 49%. This is the reason why we developed Cr/AlNd double layer anode.

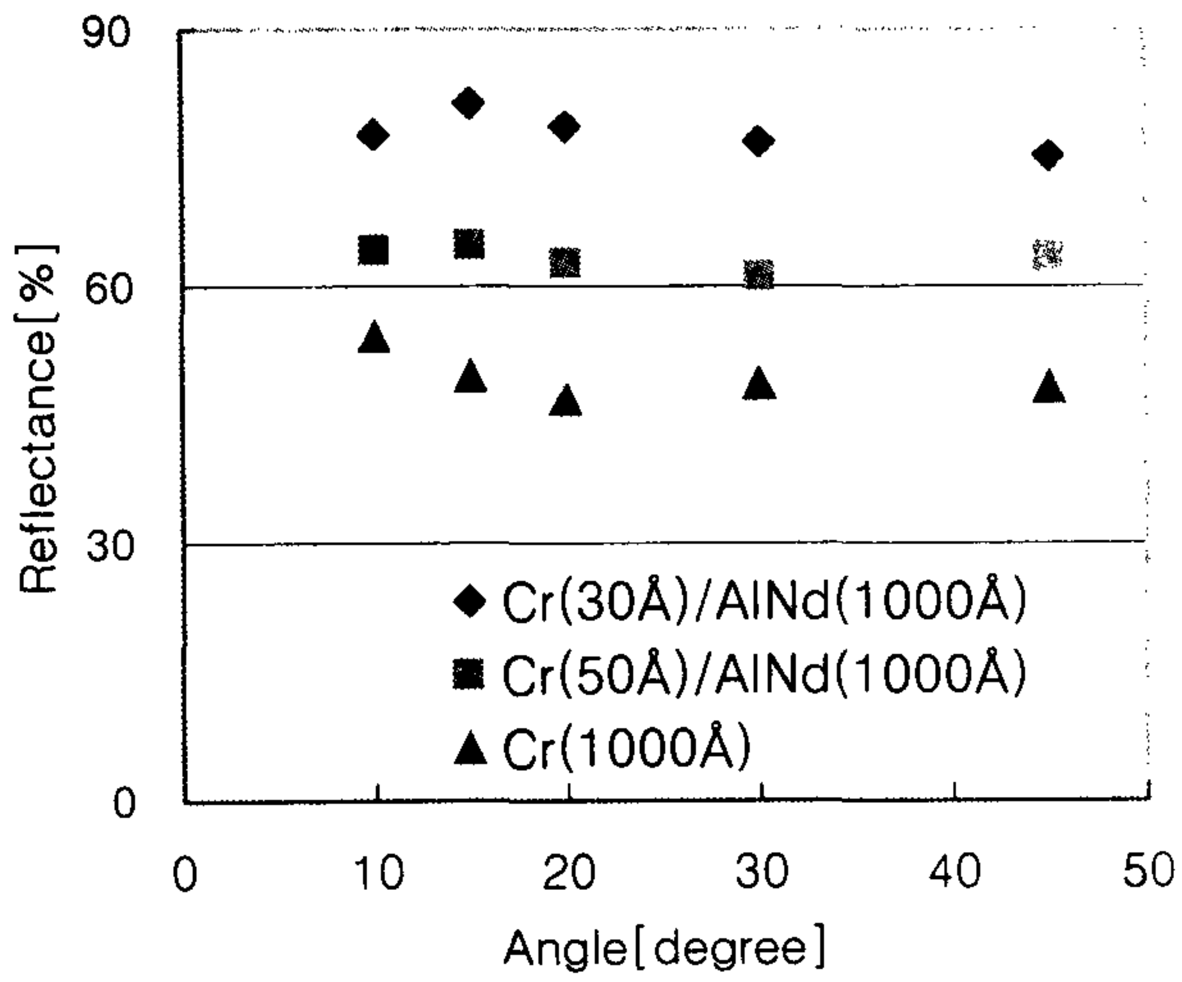

Figure 3. Reflectance of Cr thin film at θ_I

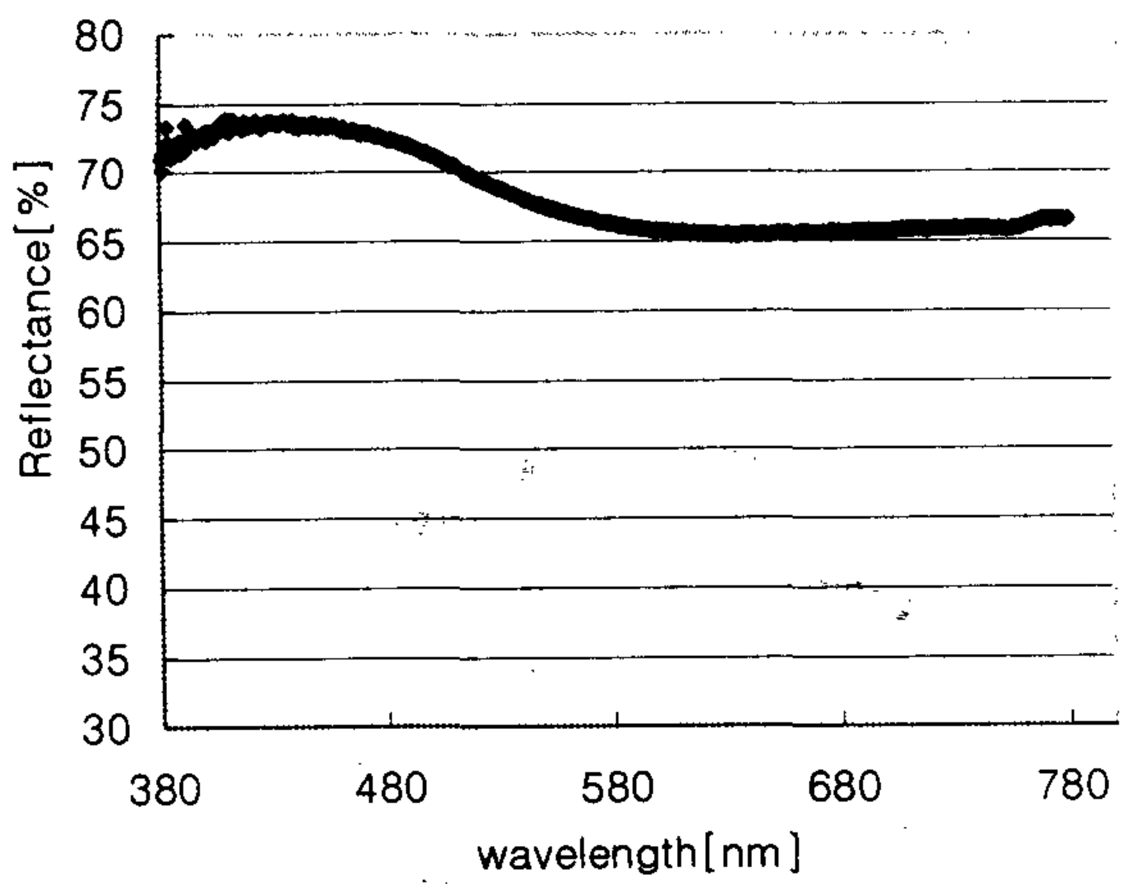

Figure 4. Reflectance of Cr/AlNd thin film

Figure 4 shows reflectance of Cr/AlNd thin film at θ_I=15°. Reflectance of blue region is higher than others. This result reveals that Cr/AlNd anode has merit that increases efficiency of blue color in AMOLED.

3.2 Work function of Cr/AlNd anode

Work function of Cr/AlNd anode measured by Riken-Keiki AC-1. Figure5 shows work function of Cr/AlNd anode. Work function of Cr(50Å)/AlNd(1000Å) has higher than that of Cr(30Å)/AlNd(1000Å). This result shows that I-V characteristics have relation to work function of Cr/AlNd anode.

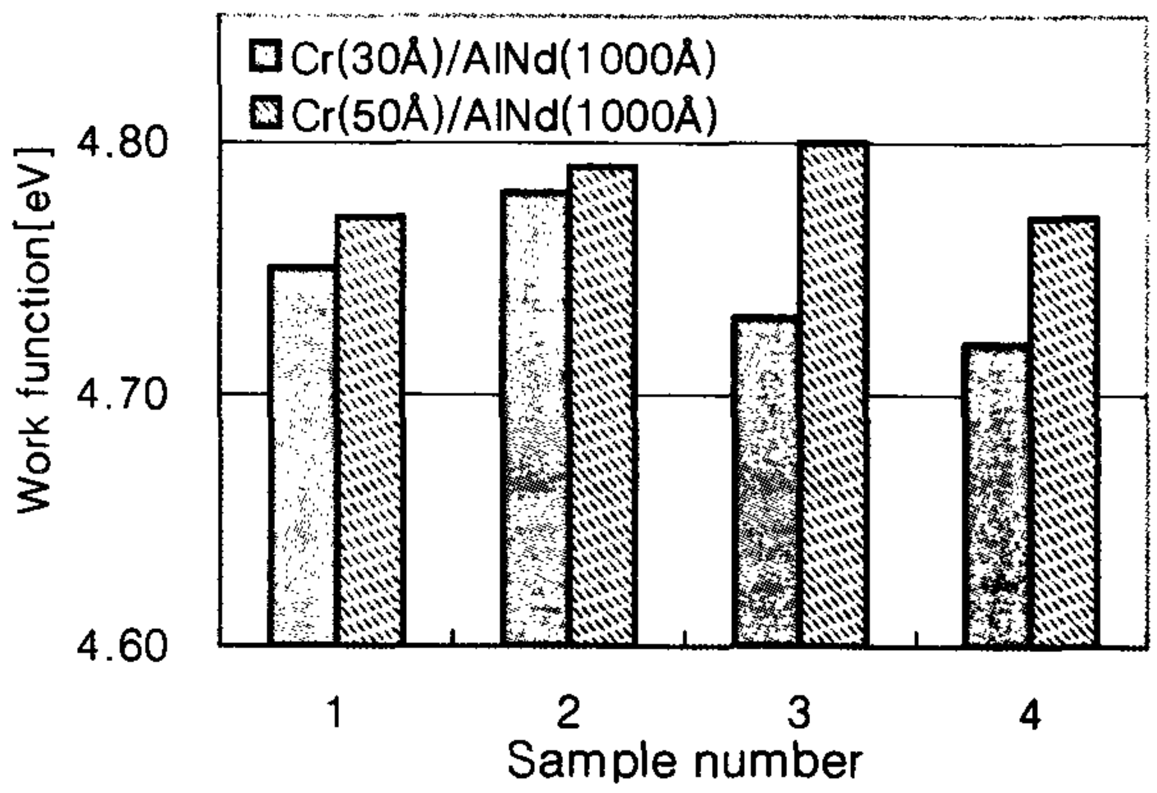

Figure 5. Work function of Cr/AlNd anode

Figure 6 shows energy diagram of OLED. It is important to match HOMO level of HIL with work function of anode. The reflective anode, which is used in this work, consists of two layers. Thin Cr layer is formed on AlNd layer and thin Cr layer plays a role as anode and AlNd does as reflector.

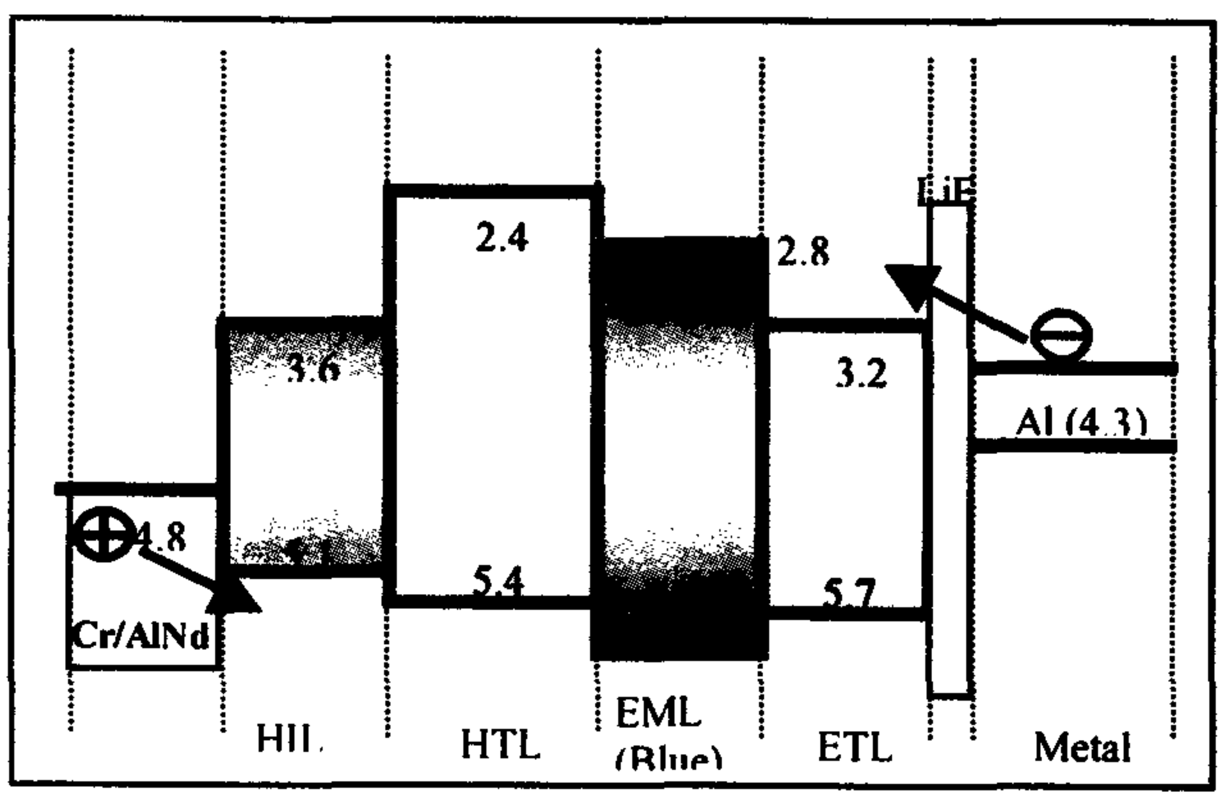

Figure 6. Energy diagram of OLED

3.3 Optimum Cr thickness of Cr/AlNd anode

Figure 7 shows Current-Voltage characteristics of OL ED which has Cr/AlNd anode.

Cr(30Å)/AlNd(1000Å)/organic layer/cathode -- Device (I)

Cr(50Å)/AlNd(1000Å)/organic layer/cathode -- Device (II)

Cr(1000Å)/organic layer/cathode -- Device (III)

Anode of device(III) is Cr(1000Å). Driving voltage of device(III) is 6.7V at $1mA/cm^2$ and that of device(II) is 7.2V at $1mA/cm^2$. Their current-voltage characteristics are very alike. These characteristics show that Cr/AlNd is a good candidate as anode.

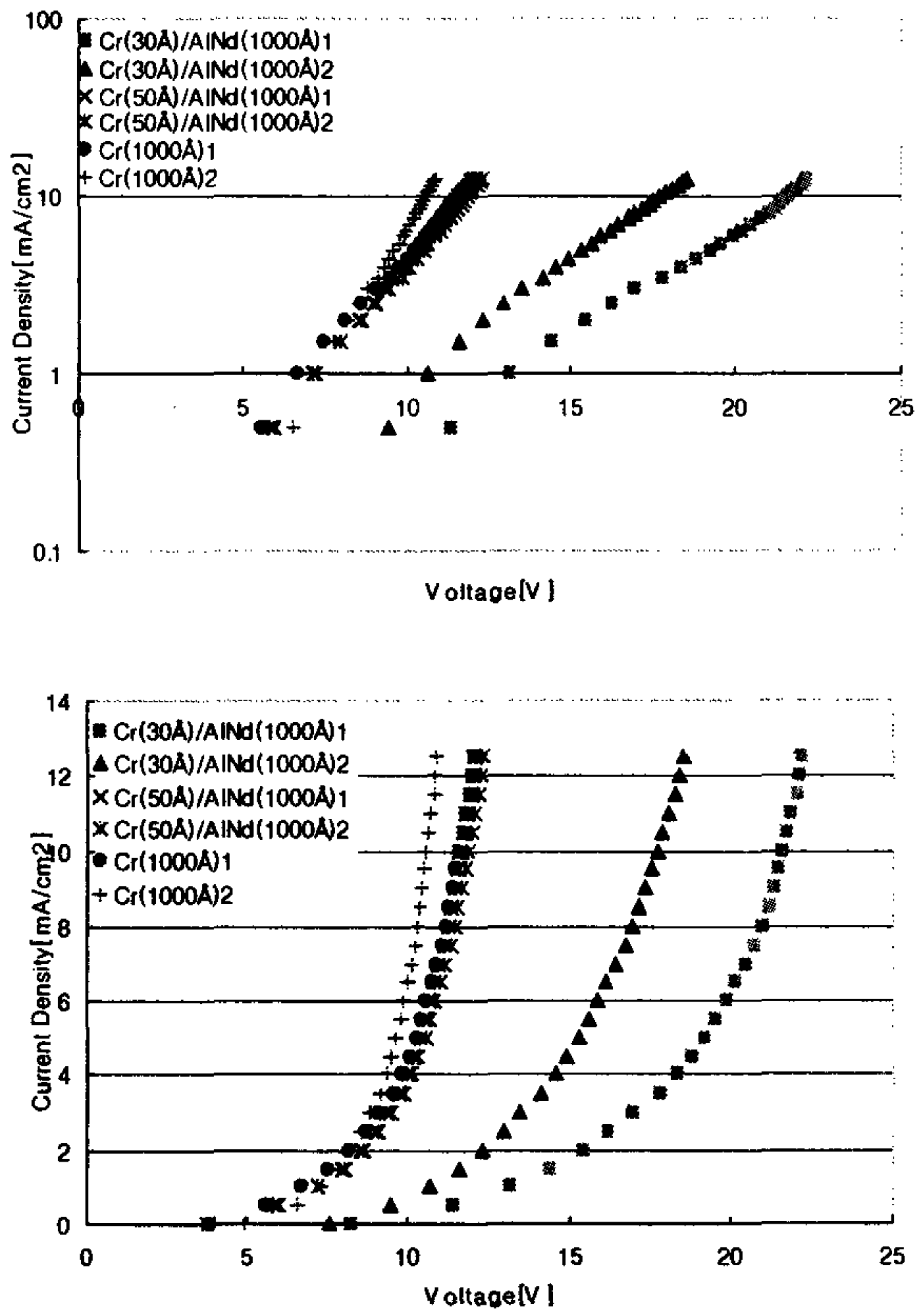

Figure 7. I-V Characteristics of Cr/AlNd Anode

The current-voltage characteristic of Cr(50Å)/AlNd (1000Å) is superior to that of Cr(30Å)/AlNd(1000Å). The thickness of Cr on AlNd should be optimized to get high efficiency. Driving voltage of device(II) is lower than that of device(I) due to higher work function of Cr(50Å)/AlNd (1000Å) anode. 30Å thickness of Cr layer is very thin so the uniformity of thickness is not good. Therefore the deviation of work function and diving voltage among samples having of Cr(30Å)/AlNd(1000Å) is high. Further study of thin Cr layer on AlNd must be performed in order to make higher efficiency TEOLED(Top emission organic light emitting diode).

4. Conclusion

We have developed a reflective anode using Cr/AlNd structure. Cr(50Å)/AlNd(1000Å) is a good candidate as anode for TEOLED. OLED device made with Cr(50Å)/AlNd(1000Å) anode shows low driving voltage and good uniformity. It is key technology in reflective anode to optimize thickness of Cr and process of deposition.

5. References

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