The effect of width and shape on the fatigue behavior of metal lines in flexible AMOLED devices

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Flexible OLED will be widely used in display area because of its flexible, lightweight and portable properties. The reliability of the OLED device is influenced by the mechanical properties such as strength or fatigue behavior of thin films and metal lines. During bending or tension, micro-cracks will generate and propagate, and then the electrical properties of the device will be compromised. Up to now, the effect of thickness and grain size on the films adhered to flexible substrate has been widely reported [1]. However, the metal line adhered to flexible substrate which used as conducting wires has not been fully investigated. The effect the width (*L*) and the shape on the fatigue behaviors of the metal line during bending should be studied to improve the mechanical reliability of flexible AMOLED devices.

In this article, Mo with different widths and shape was chosen for the metal fatigue behavior study. First, using a shadow mask, 275 nm thick Mo lines were deposited on 65 μm thick polyimide (PI) substrate. Then a 10 μm thick protective film PI was adhered on top of the Mo film, forming a sandwich structure. As shown in Fig. 1, 3, 5 and 10 μm width Mo line was chosen with different shapes of straight line; polyline and sine line. Then the multilayer structure was bent from 2000 to 100000 cycles with the bending radius (*r*) about 5 mm. As the bending cycle increases, the Mo line will start to crack or delaminate and then fracture during the bending test, resulting in the increment of electrical resistance (*R*). The metal line fatigue life (*T*) was defined as the cycles when the R/R_0 sharply increases (R_0 is the initial resistance before bending) [2].

The result shows that both the width and the shape play an important role on the *T*. As shown in Fig. 2, as the *L* increases, the *T* decreases for all metal lines. This is because that more defects such as grain boundary cracks or voids exist in thicker lines, and the cracks propagate easily during bending [3]. In addition, with the same *L*, the sine line shows the largest *T*. Especially, the sine line with *L* is 3 μm can be bent to about 95000 cycles without fracture, which means the sine line has the best mechanical properties. During bending test, the stress in polyline accumulates easily at the corner, and then cracks generate and propagate at these places, in contrast, the stress can be easily released in sine line, and the line can sustain without fracture during bending, therefore, the sine line has the largest *T*.

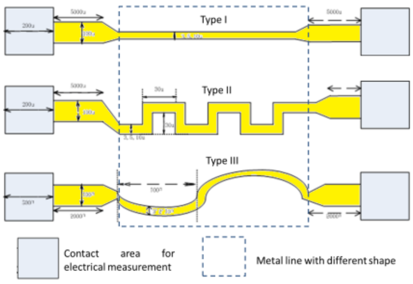

Fig. 1. Three different types of metal line

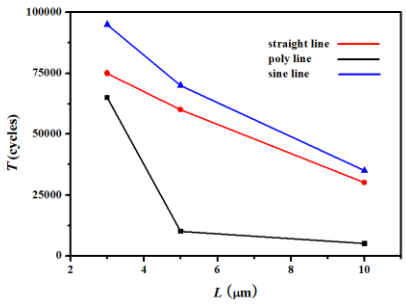

Fig. 2. The effect of line width on fatigue life

In conclusion, the effect of width and shape on the fatigue behavior of metal lines in flexible AMOLED devices was investigated and the results show that both the width and the shape play an important role on the *T*. With increasing *L*, the *T* decreases because more defects result in more micro-cracks. Additionally, sine line has the best mechanical properties due to the lowest stress localization. From the premise that the electrical properties of the lines are well maintained, narrows sine lines should be chosen to improve the mechanical properties in flexible AMOLED.

References

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