Research on Redundancy Absorption and Surface Deformation of OLED Display

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Abstract

AMOLED (Active-matrix organic light-emitting diode) is supported by PI (Polyimide) flexible substrate, which can be made into an arbitrary shape. It will cause area difference in hyperboloid or spherical CG (Cover Glass) when it is laminated to the surface. In this case, the wrinkles will occur on the bending surface. In this article, the influencing factors are analyzed by building a model in stress simulation software to compute the minimum principal stress. Besides, the design of experiment about avoiding wrinkles are done.

Author Keywords

AMOLED; CG; wrinkle; bending radius; hyperboloid; redundancy absorption

1. Background

In order to achieve full curved display, terminal products such as mobile phones and tablets need to solve the problem of wrinkles at the four corners of the screen after lamination due to stress in the X/Y directions. The size of the wrinkles directly affects the display effect of the screen. The factors that affect the size of the wrinkles include the R of the four corners of the screen, the slope of the curved surface of the CG, the bending radius of the CG, and the bending height of the CG. This solution uses the relationship between physical redundancy and simulated minimum principal stress as a criterion for judging the size of wrinkles, and achieves the ultimate display effect at the four corners by adjusting the module stacking design and CG design.

2. Mechanism Analysis

The main influencing factors of wrinkles are the physical redundancy of materials (area difference); the compressive stress of materials (bending depth, bending curvature and camber slope). The semi-finished product is attached to the hyperboloid position from the plane. Due to the redundancy, the compressive stress tangent to the R-angle bending arc will be generated at the hyperboloid position after the semi-finished product is combined. When the curvature and height of the CG increase, the compressive stress will increase accordingly. When it exceeds the limit of the semi-finished product's own compressive capacity, the semi-finished product will produce wavy folds (as shown in Figure 1). Under the condition of certain redundancy, the smaller the minimum principal stress of the material (the deformation resistance of the material), the more serious the wrinkle; When the minimum principal stress is fixed, the greater the redundancy, the more serious the wrinkles.

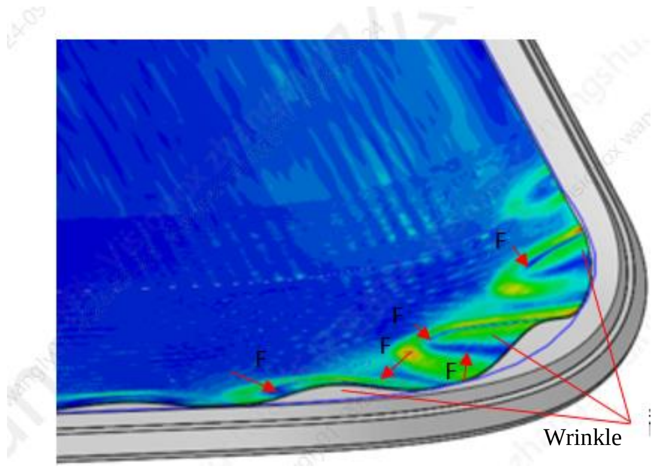

Figure 1. Schematic diagram of wrinkles appearing in the corner

3. Research Methodology

1. The mechanical simulation software is used to establish a curved surface simulation model. The influencing factors of minimum principal stress including integrated materials, CG curvature, bending radius, etc. By studying the relationship between the minimum principal stress and wrinkles of the screen module stack on the curved surface (reference principal stress criterion: the principal stress in the normal direction is the minimum principal stress $\delta 1$, the principal stress in the tangential direction is the maximum principal stress 82, the tension state must meet $\delta 1>0$; the wrinkle state must meet $\delta 1 \leq 0$, $\delta 2 > 0$, the relaxation state must meet $\delta 1 \leq 0$, $\delta 2 \leq 0$), this model meets the stress distribution in the wrinkle state (as shown in Figure 2).

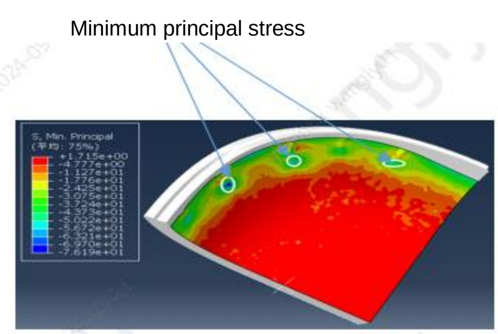

Figure 2. Simulation diagram of stress distribution in the wrinkle state

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2. The 3D drawing software is used to divide the surface equally and flatten it to calculate the area difference between the plane and the curved surface (as shown in Figure 3). The quantitative value of the wrinkle size is not only related to the minimum principal stress but also to the area difference between the curved surface and the plane. By studying the relationship between redundancy and CG parameters (bending radius R, bending height H, bending angle, arc width W), Figure 4 and equation 1 shows the relationship between the CG parameters and the redundancy. The redundancy is proportional to H, inversely correlated with R, and positively correlated with the bending angle. The redundancy can be quickly adjusted by adjusting the parameters.

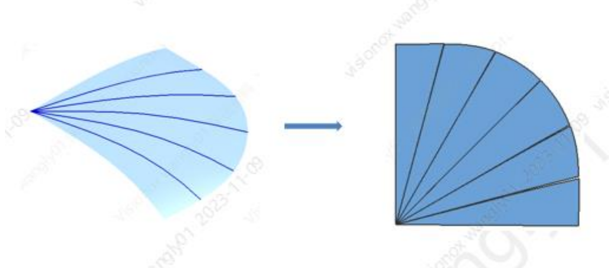

Figure 3. Schematic diagram of calculating the area difference

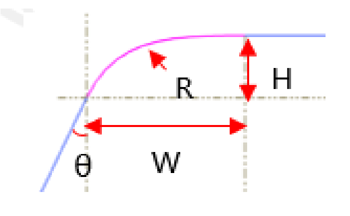

Figure 4. Relationship between W, R, H and θ

$$W = \frac{R(1-cos\theta)+H*cos\theta}{sin\theta} \quad (1)$$

3. The effect of OCA (Optical adhesive) deformation on wrinkles through slicing (as shown in Figure 5 and 6) is analyzed. Due to the fluidity of OCA, when the curved surface is bonded, the OCA overflows at the edge of the arc area, causing the edge of the screen to warp, the curvature of the screen stress release is reduced (the bending radius is increased), the actual height and redundancy are reduced, and the corresponding wrinkles are reduced. The greater the inward shrinkage of the OCA edge, the more difficult it is for the edge of the screen to bond with the CG, the greater the screen stress release, and the less likely wrinkles are to occur.

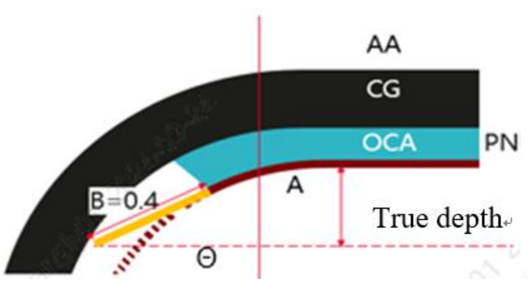

Figure 5. Effect of OCA retraction on wrinkle

Figure 6. Microscope photo of module slicing

The influence of material support on wrinkles was analyzed by slicing (as shown in Figure 7). The shrinkage of the POL (polarizer) and BPF (Back Plate Film) leads to the weakening of the strength at the edge of the screen, and the stress of the screen edge resisting deformation is reduced during bonding, resulting in yield deformation and increased wrinkles at the edge; the shrinkage of the polarizer causes the OCA to exceed the polarizer and directly bond to the screen, increasing the Z-direction deformation of the screen and increasing wrinkles.

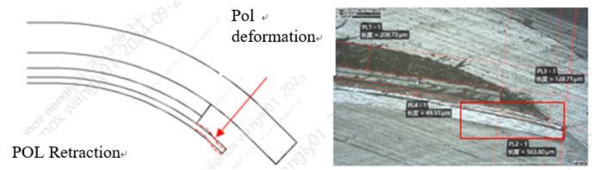

Figure 7. Effect of POL & BPF retraction on wrinkle

4. Through DOE (Design of Experiment) comparison, the size of wrinkles are quantified, and the relationship between the two and the extreme position are analyzed. The lamination position corresponding to the extreme wrinkle position sample under a single condition is analyzed to calculate the redundancy and stress simulation, and the extreme wrinkle relationship is built through fitting of multiple groups of DOE sample data. Our company has verified more than 100 extreme positions to deduce the wrinkle relationship that can meet the surface redundant wrinkle threshold and guide the module stacking design.

4. Conclusion and Discussion

Through the above method and DOE data fitting, a wrinkle relationship is constructed (as shown in Figure 8). Through this relationship, it is concluded that the range above the wrinkle OK limit is a wrinkle-free area, the range below the wrinkle NG limit is a wrinkle area, and the area between the two curves is a wrinkle & non-wrinkle mixed area, which can quantify the surface wrinkles. This paper combines simulation modeling, theoretical calculation, experimental verification, and slice analysis to realize the absorption of redundant OLED surface display and the compensation method of curved surface deformation.

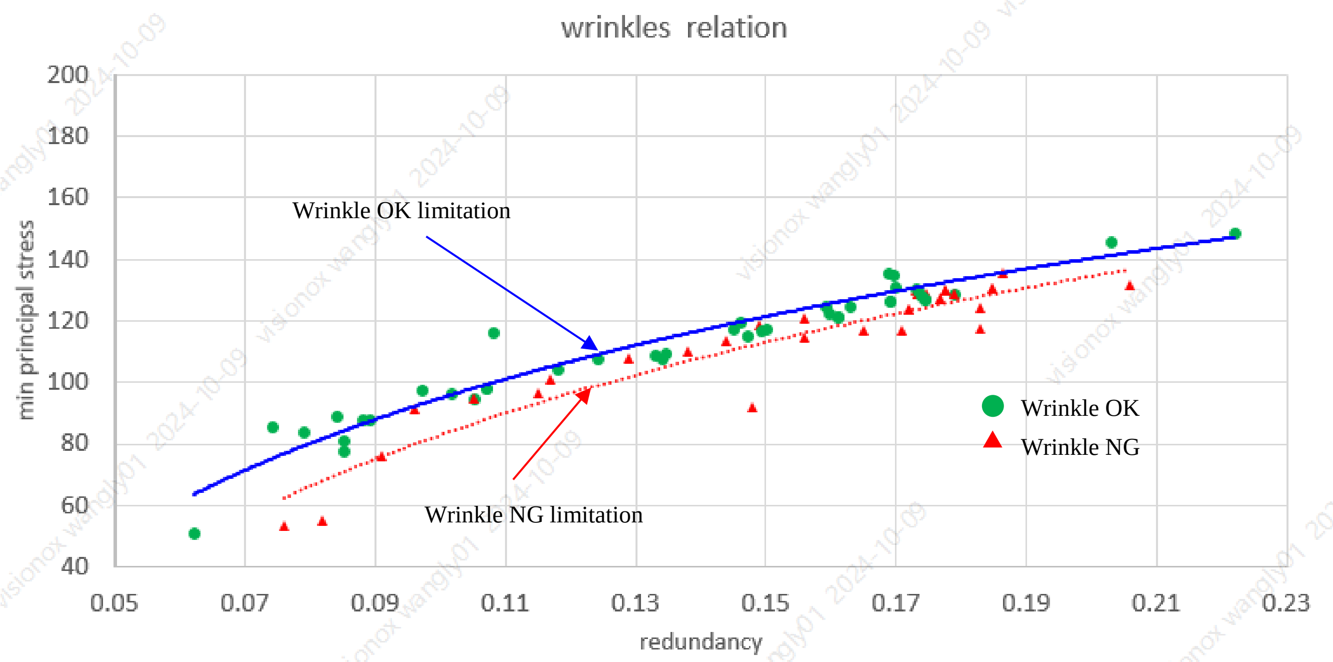

Figure 8. Scatter plot of wrinkle OK or NG judgment

5. Impact of The Research

The main impact of the research including: Redefine the rules of curved surface design, guide subsequent researchers in the design of curved surface lamination. Studying the laws of wrinkles can expand researchers' development ideas for wrinkles and guide the industry to explore deeper full-curved surface displays.

6. Acknowledgement

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7. References

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