The Technological Process of Silver Electrode Printing on Touchscreens

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Abstract: A new type of metallic screen embedded in the non-metallic screen, with a mesh count of 230-380 mesh/inch and a wire diameter of 19 μm with an opening rate of 39%, is found through the comparative experiment. The screen has high resilience, suitable mesh count and moderate opening rate. This kind of screen can not only ensure the off-screen effect, but also ensure the high resolution of stencil and printing.

1. Introduction
The silver electrode of screen printing on touchscreen requires to reduce the diffusion of silver paste printing film. In order to improve the printing precision and reduce the diffusion of silver paste printing film, high viscoelastic paste is usually used. However, the off-screen effect of high viscoelastic paste is poor, so we need to use the screen printing plate with high strength and low plastic deformation for platemaking. However, due to the high hardness of the wire, it is difficult to process into a screen with high mesh count. The improvement of mesh count in silver electrode printing process is limited. For the same mesh count, we can improve the permeability and off-screen effect by reducing the wire diameter and increasing the opening rate of the wire mesh. Through the experiment, it is found that although this method can improve the image resolution of the screen printing plate, it cannot improve the precision of the printing product. In this paper, we experimentally optimize the mesh count of the screen to ensure both the off-screen effect and the high resolution effect of the stencil and printing.

2. Optimization of key factors of electrode screen printing on touchscreens

2.1. The mesh count of screen
Screen is the basis of printing. Only choosing a good screen can improve the precision and quality of printing products. Screen parameters mainly include mesh count MC and wire diameter d. The minimum size of dot that can be replicated by screen printing is mainly determined by MC and d. The value of MC reflects the number of dots that can be printed and replicated in unit length. The larger the MC is, the smaller the dots will be.

According to the relationship between wire diameter d and aperture ω, the screen can be divided into three categories:
(1) The aperture of the screen is larger than the wire diameter, ω > D.
(2) A situation in which the two differ little or are equal, ω ≅ D.
(3) The aperture is smaller than the wire diameter, ω < D.

Calculate the mesh area ratio of the above three kinds of screen to get Table 1-1.
Table 1-1 Relationship between mesh count, aperture diameter, wire diameter, screen thickness and opening area ratio

| mesh count (mesh/cm) | aperture diameter (μm) | wire diameter (μm) | screen thickness (μm) | opening area ratio A (%) | Relation of ω and d |
|----------------------|------------------------|-------------------|-----------------------|-------------------------|---------------------|
| 350S                 | 20                     | 18                | 24                    | 27.7                    | ω > d               |
| 350T                 | 18                     | 19                | 35                    | 23.7                    | ω ≅ d               |
| 350HD                | 16                     | 25                | 40                    | 15.2                    | ω < d               |

It can be seen from the value of A that in the printing process, when the aperture is much larger than the wire diameter, the dot is easier to form a complete ink dot through the mesh, that is to say, the printing resolution is higher than that of the screen with wire diameter larger than the aperture, and it is more suitable for the replication of the smaller lines in the screen printing.

The printing experiment was carried out with the screen of 350 mesh/cm and 19 μm wire diameter. The data obtained are shown in Table 1-2.

Table 1-2: The spread of 350 mesh/cm and 19 μm wire diameter

| linewidth/spacing mesh | wire diameter | emulsion thickness | design value of line width |
|------------------------|---------------|-------------------|---------------------------|
| 100 μm                 | 350 μm        | 19 μm (5~10 μm)   | 80 μm                     |

In the experiment, there is a 10-20 μm diffusion of lines. According to the principle of screen printing, fine line printing is only to transfer the paste of the lower part at the screen opening to the substrate, while the paste of the upper part remains at the opening. In order to prevent the diffusion of the paste, we will generally improve the viscoelasticity of the paste so that the printing is not affected by the surface free energy of the substrate to maintain the shape transferred to the substrate. However, the off-screen effect of high viscoelastic paste is poor. If a large screen spacing is adopted, the printing dimensional precision will be affected and the service life of the screen will be shortened. At this time, we can consider using high-strength screen to solve this problem. Generally speaking, the screen with high strength and low plastic deformation is the best. The tensile strength of SupermeshHS (opening rate of 60%) with wire diameter of 14-25 μm and mesh count of 230-380 can reach 3000 N/mm². Because the material of this kind of screen is too hard, it can't be made into the screen with high mesh count, so its opening rate is about 60%. Therefore, the screen with mesh count of 230-380 mesh/inch has a lower diffusivity during printing.

2.2. The relationship between printing precision and screen opening rate

Comparing two kinds of screens both with 325 meshes, one is the wire diameter of 28 μm and the opening rate of 41%, and the other is the wire diameter of 16 μm and the opening rate of 63%. The high viscoelastic (400Pa·s) PDP is printed, and silver paste and substrate are used as stripping substrate (The designed value of line is 50 μm, and the thickness of photosensitive emulsion is 15 μm). The effect after printing is shown in Figure 1 and Figure 2:
The screen with high opening rate does increase the resolution of photosensitive emulsion, but it is easy to cause lateral diffusion after printing and reduce the printing precision if the opening rate is too large. The comparison after printing is shown in Figure 3 and Figure 4 (The black part is the printing part).
Figure 3 Screen with the wire diameter of 28 μm and the opening rate of 41%

Figure 4 Screen with the wire diameter of 16 μm and the opening rate of 63%

We can't sacrifice our printing resolution in order to obtain high resolution of the stencil. Therefore, we need to find a kind of screen, which has high resilience, high mesh count and high opening rate. We can choose a way to embed the metallic screen in the non-metallic screen, which can not only obtain good resilience, but also ensure the high resolution of the stencil and printing. As shown in Figure 5, the resilience of HS-D500 screen is 2.3 times of that of general products. The wire diameter of the screen is 19 μm, and the opening rate is 39%. When the plate spacing is 2.5 times of the standard value, no plastic deformation will occur. After printing, the screen plate can still restore its original size. The screen has the advantages of improving the off-screen performance, improving the printing dimensional precision, improving the printing resolution and prolonging the service life of printing plate.
3. Optimization of the technological process of electrode screen printing on touchscreens

3.1. Using high viscoelastic paste to reduce the diffusion of lines
If the viscoelasticity of the paste is poor, there will not be too much influence after just printing, but when it dries, the line will appear diffusion. Increasing the viscoelasticity of paste can reduce the influence of surface tension of substrate and reduce the diffusion of lines after printing.

3.2. Selecting the appropriate squeegee to improve the permeability of the paste
The principle of screen printing is to use the relative movement of squeegee and screen to produce an internal pressure on the paste, so as to press the paste over the screen to the substrate. The larger the viscoelasticity of the paste is, the lower the permeability of the screen will be. Therefore, in order to improve the permeability of the paste, it is necessary to increase the internal pressure of the squeegee on the paste. The smaller the inclined angle of squeegee is, the greater the internal pressure on the paste will be. Therefore, it is necessary to choose a proper squeegee to improve the viscoelasticity of the paste.

3.3. Other issues requiring attention
(1) In order to coordinate with the high viscoelastic paste, the emulsion layer of the screen printing stencil has to be more resistant to dissolution. If the solvent resistance is poor, the stencil is prone to swelling (The volume of the object becomes larger after water absorption), which will result in poor resolution of the stencil, resulting in uneven line thickness or even wire breakage.

(2) Different from low viscoelastic paste printing, when printing with high viscoelastic paste, as long as there is a little bit of photosensitive emulsion residue or a little pollution or foreign matters at the opening of the screen surface, it will cause wire breakage. Therefore, attention should be paid to improving the process precision in the exposure and development process, especially the dust-proof precision. The cleanliness of the workshop has strict requirements, which should reach more than 100000 levels.

(3) The temperature of the workshop is generally controlled at 23 ± 3 ℃, and the relative humidity is 50-65%.

(4) When cleaning the screen, use a solvent that is not easy to dry and wash the screen with a spray, and wipe the emulsion surface to the minimum to improve the service life of screen printing plate.
4. Conclusion
This paper focuses on the parameters that affect the screen printing precision of silver electrode on touchscreens, mainly mentions the factors that affect the geometric characteristics of the screen, and discusses the influence of screen mesh count, wire diameter, opening rate and other parameters on the screen printing precision of silver electrode. The geometric characteristics of screen is the basis of screen printing. Based on the analysis of mesh count and wire diameter, the calculation formula of minimum dot is compared, and the reasonable parameter range of silver electrode printing on touchscreens is proposed. This experiment provides a reference for improving the precision of screen printing. It is proposed that the most suitable screen type for silver electrode screen printing is the metallic screen with high resilience embedded in non-metallic screen, which provides theoretical basis and guidance for the fine printing process.

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