» New Products

# Development of Thin Copper Foil DF-TSH for Fine Pattern Circuit Boards

## 1. INTRODUCTION

Recently, the width of circuit patterns and the space between them have been getting thinner and thinner along with increasing the density of circuits on printed circuit boards of mobile devices as a typical example, and the demand for the fine pattern circuit board has already started to grow. In general, the circuit of fine pattern circuit board is formed with copper foils or copper plating. Copper foils are roughly classified into electrodeposited copper foils and rolled copper foils. In the application of fine pattern circuit boards, the electrodeposited copper foil is mainly applied, which can be used even for a large size circuit board because it is excellent in productivity. Built on the electrodeposited copper foil (glossy on both side) technology, we have been producing the surface processed copper foil - known as F-WS - for the printed circuit board applications. This technology has an added functionality offered by its surface treatment. We have received high marks from our customers on the F-WS.

It is effective to make the copper foils thinner against finer circuit patterns for a circuit board built with copper foils. In the Subtractive method, which has been used for processing a circuit board, 12 μm thick copper foils were mainly used in circuit forming process, in which resist patterns were processed by photo-lithography and unnecessary copper was removed by etching. This is a simple process to enable the low-cost production of circuit boards. In this process, L&S, which indicates the width of circuit pattern and the space between circuit patterns, can be as small as 35/35 μm in production. For producing further fine circuit pattern, copper foils with 9 μm or less in thickness are necessary to be applied. In this case, because of the lower strength of copper foils, problem occurs such as the copper foils may get wrinkled and curled making the handling very difficult in transfer process or layering process in which a sheet of copper foil is laid on a resin base board. In addition, because common copper foils have such characteristic that their strength gets lower after heating, thin copper foil circuit boards have the defect of reduced rigidity after heating in the layering process.

On the other hand, MSAP method has been already spread for forming fine pattern circuits of L&S = 30/30 μm or less, in which circuit patterns are formed by copper plating by using thin copper foils with carrier film as a seed layer. The MSAP method has been mainly used for a package board on which semiconductors are mounted. However, recently, it has been adopted for a main board as well along with higher density packaged mobile devices with enhanced performance and its application range is spreading. However, the MSAP method had a problem of high cost although it exceled in forming fine pattern circuits. And when applying copper foils with carrier film, extra time is needed for the peeling process when producing a circuit board.

We have successfully developed the copper foils which enables further fine pattern circuits by the conventional Subtractive method.

## 2. FEATURES

DF-TSH, our thin copper foils for fine pattern circuit boards is the thin copper foils with 6 μm in thickness, which can be handled without any copper carrier film and is realized by our original electrolytic structure control technology to provide not only a high tensile strength but also a high elongation. Typical mechanical properties and physical properties of DF-TSH are shown in Table 1 in comparison with other copper foils.

(1) High tensile strength

The tensile strength of DF-TSH is approximately 1.5 times higher than that of F2-WS, our present copper foil, however, its higher elongation which usually is the tradeoff for a higher tensile strength is as high as 3% which is a high value in comparison with other high tensile copper foils.

**Table 1 Mechanical properties and physical properties of DF-TSH and other copper foil.**

| Items for Evaluation | Thin Copper Foil for Fine Pattern Circuit Boards, DF-TSH | | Our Present Copper Foil, F2-WS | Electrodeposited Copper Foil, A |
|---|---|---|---|---|
| Thickness /μm | 6 | 12 (for reference) | 12 | 12 |
| Tensile strength /MPa | 490 | 490 | 320 | 370 |
| Elongation /% | 3 | 6 | 8 | 6 |
| Roughness /μm | 2.0 | 2.0 | 2.0 | 3.0 |

With these excellent properties of DF-TSH, the generation of wrinkles can be controlled even in either the transfer process or the layering process of fine pattern circuit boards and can handle the thin copper foils with thickness as thin as 6 μm in the same way as usual.

(2) Excellent processing for fine pattern circuits by conventional process

DF-TSH is excellent in etching characteristic to form fine pattern circuits because of its thin thickness of 6 μm. Figure 1 shows effects of copper foil thickness for a pattern trailing length *D* in the pattern circuits formed by the conventional process of the Subtractive method. In general, the cross section of pattern circuits formed by the Subtractive method has a trapezoidal shape as shown in the Figure and the pitch of pattern circuits can be narrower when the trailing length is shorter. The trailing length of a foil thickness 6 μm is reduced by 40% in comparison with that of a foil thickness 12 μm at L&S = 30/30 μm. Furthermore, the pattern width dispersion is improved to be 50% or less as shown in Figure 2 We have already confirmed in the actual manufacturing process of fine pattern circuit boards that the L&S = 30/30 μm could be formed by using DF-TSH of foil thickness 6 μm by the Subtractive method. With this process, compared with the conventional MSAP method, the cost of the pattern circuit forming process can be drastically reduced. Further, the extra time to peel the copper carrier film can be saved.

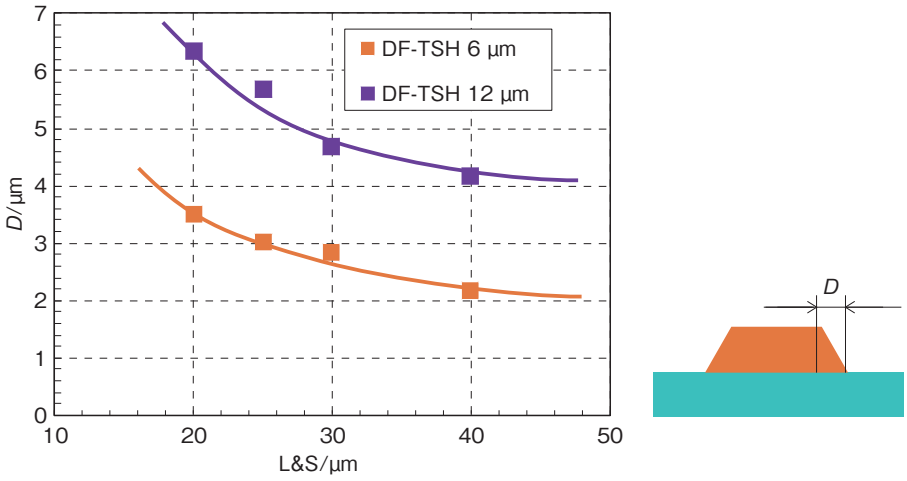


**Figure 1 Effect of the copper foil thickness for pattern trailing length *D* by the Subtractive process.**

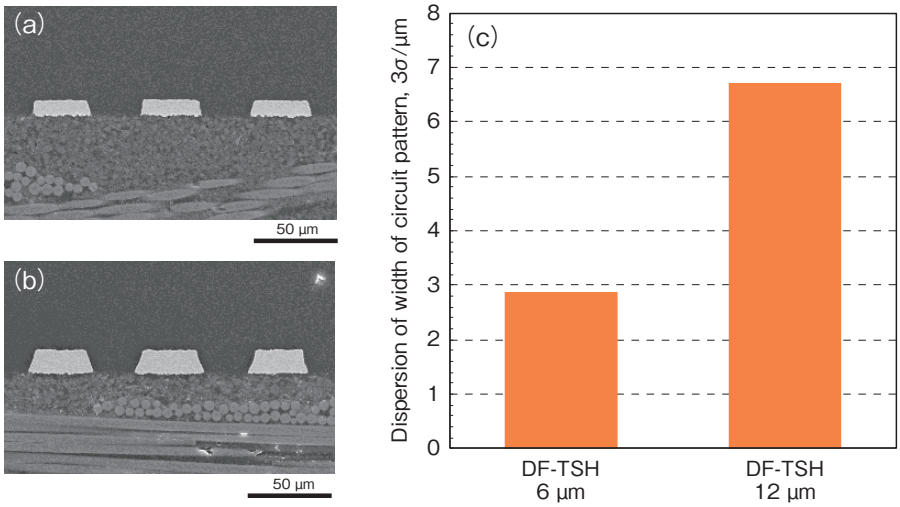


**Figure 2 Fine pattern formation on L&S = 30/30 μm by the Subtractive process.**
**(a) DF-TSH 6 μm**
**(b) DF-TSH 12 μm**
**(c) Effect of copper foil thickness for a pattern width dispersion by the Subtractive process.**

(3) High thermal stability

Figure 3 shows the heat softening curves of 1-hour heating under various heating temperature. In general, in the layering process of pattern circuit boards, the hot pressing process is carried out under 170°C to 220°C. Heat and pressure of the press melt resin and thermoset to stick the copper foil onto the resin base tightly. DF-TSH keeps its tensile strength even after heating at 200°C at approximately 1.5 times higher than that of our present copper foils. And, it kept its tensile strength even after heating at 200°C at approximately 1.8 times higher than that of the electrodeposited copper foil B whose tensile strength before heating is equivalent to that of the DF-TSH. Because of this high thermal stability, DF-TSH keeps its high tensile strength to control the defect caused by lowered rigidity of pattern circuit boards even after being exposed to the heat in the layering process of pattern circuit boards.

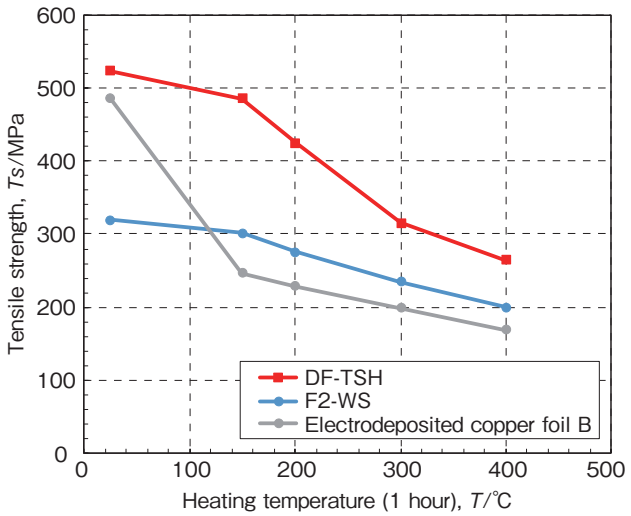


**Figure 3 Thermal stability of DF-TSH compared with other electrodeposited copper foils.**

(4) Supply of fine copper foils in the form of sheets

Improving the tensile strength of our copper foils, we have realized the supply of 6 μm thick copper foil in the form of sheets, which was very difficult in the past. This high tensile copper foil can be used in the conventional manufacturing process of pattern circuit boards without any changes.

## 3. CONCLUSION

DF-TSH, a copper foil for fine pattern circuit boards, has higher tensile strength in comparison to conventional electrodeposited copper foils as its featured property. With this property, the generation of wrinkles can be controlled even when either transferring or layering in the manufacturing process of pattern circuit boards and can handle the thin copper foil of thickness as thin as 6 μm without a carrier copper film in the same way as usual. Furthermore, DF-TSH is excellent in forming fine pattern circuits because of thickness as thin as 6 μm and can form the pattern circuits of L&S = 30/30 μm by the conventional process of Subtractive method. Now, we have DF-TSH of 6 μm in thickness in addition to that of 9 μm in thickness in our line-up and package them either in a roll or in a sheet for shipping.

We offer the optimum material constructed for customer's requirement specifications based on our manufacturing technology acquired over many years of experience such as with or without anti-corrosion processing and surface roughening processing.

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