As originally published in the IPC Proceedings.

New Technology to Improve Etching Performance Using Shiny Side Surface Treatment for HDI

Keisuke Yamanishi
Nippon Mining & Metals.Co., Ltd.
3-3-1 Shirogane-cho, Hitachi City, Ibaraki, Japan
Telephone No.: *81-294-24-1131
E-mail:yamanisi@nikko-metal.co.jp

Abstract
This paper discusses a new technology to improve etching performance using shiny side surface treatment on copper foil. Until now, a lot of electro-deposited copper foils (ED foil) with very low profile on matte side have been introduced to the market to obtain fine line products such as HDI. In addition to copper foil thickness, roughness of matte side is thought to be a key factor to improve etching performance. However, our new technology is quite unique and different from other methods to obtain narrow traces. Using new technology, 30 micron pitch circuits could be obtained using 9 micron copper foil.

Experimental
(1) Sample preparation flow and test condition
Copper foil was laminated onto coverlay to make FCCL(flexible copper clad laminate). The flow of the sample preparation was shown below.

Copper foil → Coverlay press → resist spin coating → UV exposure → Development → resist baking → Etching

*Mask pattern: 30 micron pitch (Line/space=25/5)
40 micron pitch (Line/space=25/15)
50 micron pitch (Line/space=33/17)

*Etching solution condition
$FeCl_3$ 37wt%
Temp. 50C
Baume scale 40 Be
Spray 0.15Mpa

(2) Copper foil samples
In order to verify the effect of surface roughness of copper foil, different type foils were chosen for the test shown in Table 1. Two foils were chosen from RA (rolled copper foil) and two foils from ED.

Table 1 Type of copper foil used for etching test.

Copper foil sample	Type of copper foil	Surface treatment
BHYA	RA (Rolled foil)	Smooth type
BHY	RA (Rolled foil)	Regular treatment for RA
Special ED	ED (Flat type)	Regular treatment on Flat type ED
Standard ED	ED (Standard)	Regular treatment on Regular ED

(3) Etching performance evaluation
Surface morphology was investigated by SEM on the matte side of the samples shown in Figure 1. It is clear that roughness of ED was quit bigger than that of RA. The difference between BHY and BHYA was relatively small compared to ED.
After etching, line width and the length only for the tail along the circuit was measured to obtain etching factor. Etching factor was defined as shown in Figure 3.

From the etching test results, etching factor improved when matte side surface roughness decreased. Flatter foil seemed to be better to create narrower traces. So, flatter and thinner copper foil has been used to make narrower traces for such as COF application and packaging materials. Recently it was found that 30 micron pitch seemed to be the limitation for the subtractive method, especially for COF industry. Thus, new technology should be investigated soon to overcome the limitation.

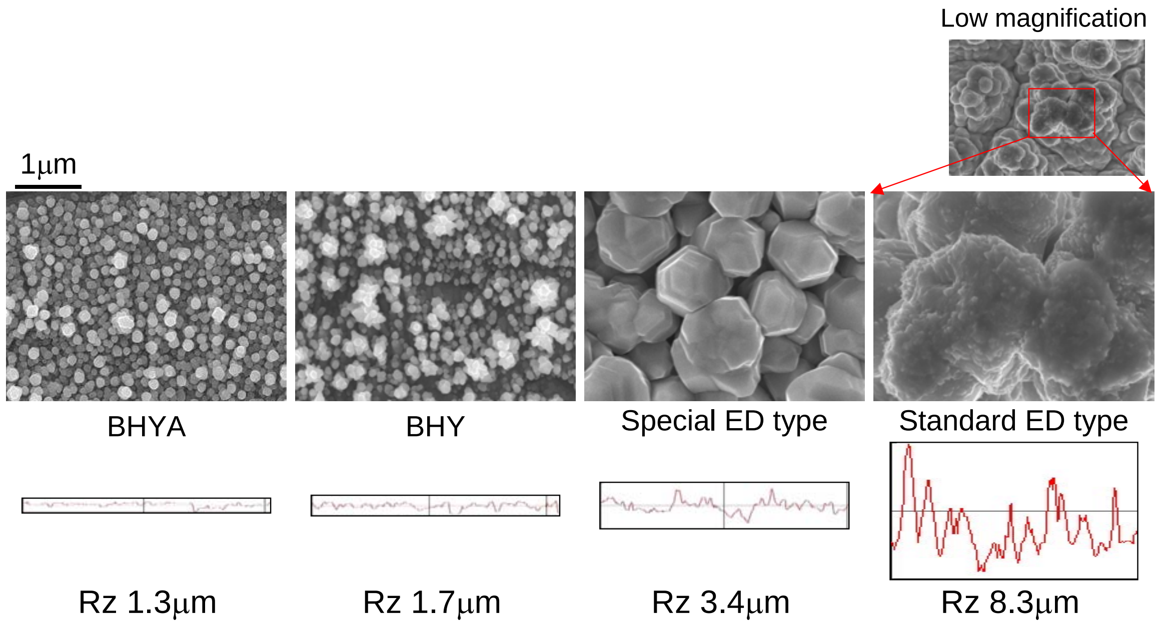


Figure 1 Comparison among various copper foils with regards to different surface roughness.

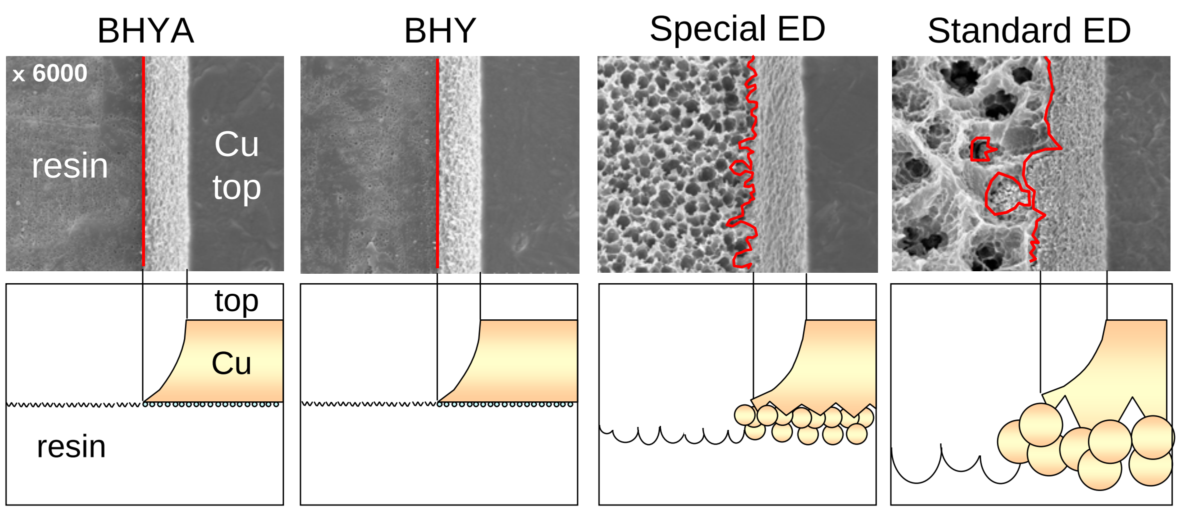
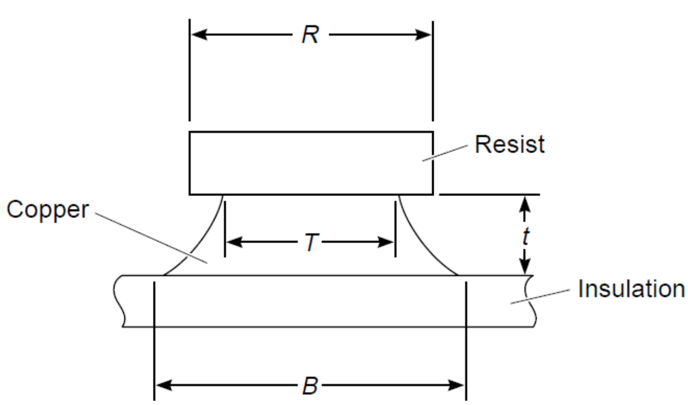


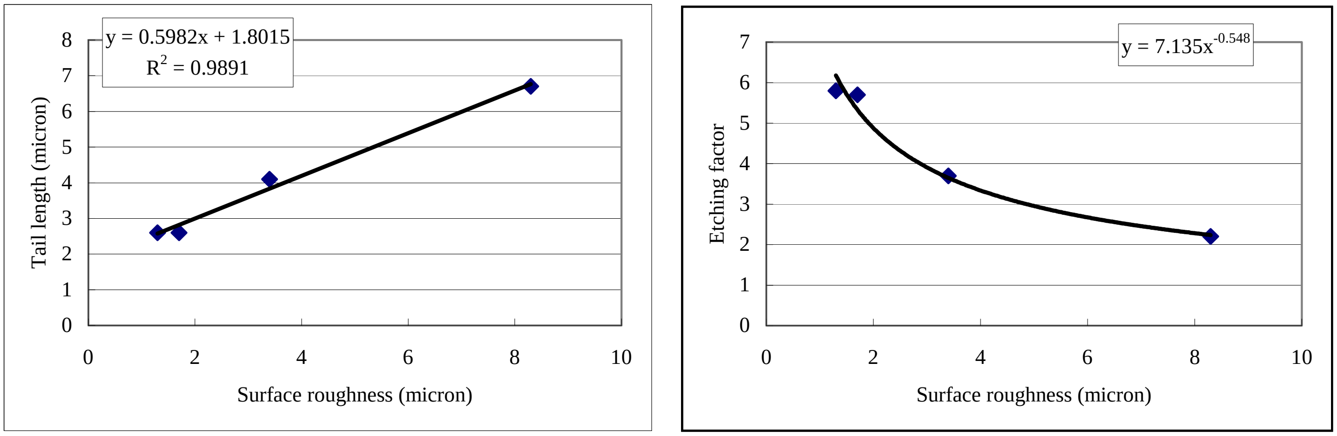
Figure 2 the effect of surface roughness on matte side of the copper foil on etching performance. (60 micron pitch pattern)



T : width of the trace on top
R: width of resist
t: thickness of copper foil
B: width of the trace on bottom

Etching factor = 2t/(B-T)

Figure 3 the definition of etching factor.



	BHYA (RA)	BHY(RA)	Special ED	Standard ED
Etching factor	5.8	5.7	3.7	2.2
Etching tail length (micron)	2.6	2.6	4.1	6.7
Surface roughness (micron)	1.3	1.7	3.4	8.7

Figure 4 the results of etching factor using different foils.

(5) Effect of etching solution, direction of copper foil, and grain structure on etching performance

In order to develop etching performance, three factors were investigated to affect on etching factor. Type of etching solution, circuit direction, and grain structure of copper foil were determined. 30 micron patter mask and 9 micron RA copper foil were used for the test. Generally, new etching which was told to have anisotropic etching property was the best, second was ferric chloride, the last was cupric chloride. However, we could not see any difference on etching performance. In the same way, the effect of circuit direction was determined. It was not found any difference on the etching performance with regards to direction of the circuit. The last one was effect of grain structure. There were two copper foil chosen for the test. One was HA foil which had very large re-crystalized grains, the other was HS foil which had layered structure related to rolling process. Even though the grain structure was so different, the etching factor for each did not have any difference.

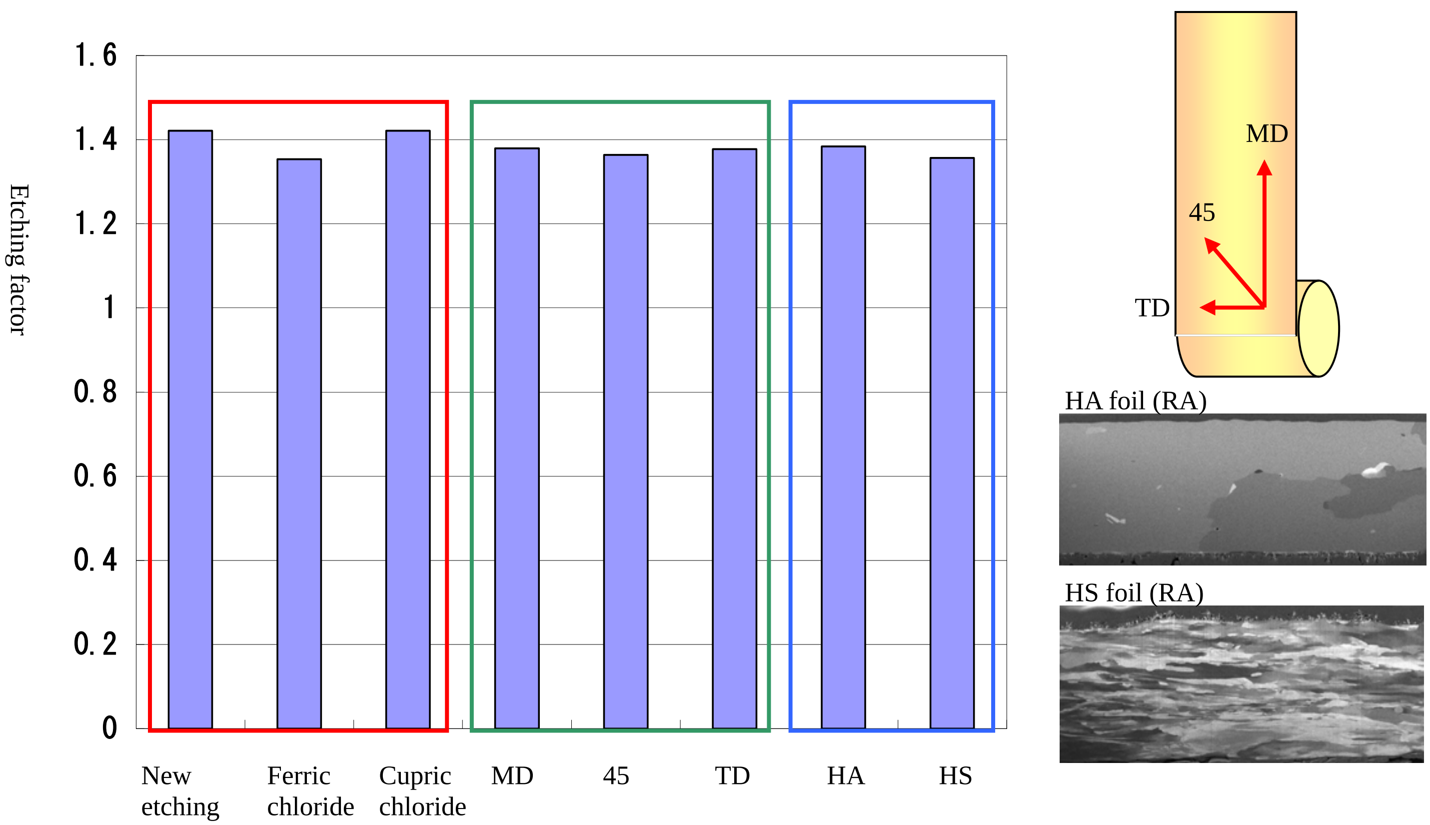


Figure 5 The effect of various factors on etching factor.

(4) Idea of the new etching technology

From our results, the assumed major factors (etching solution, direction of circuit, and grain structure) for etching did not affect on the actual etching performance. Thus new approach should be considered to overcome this situation. The followings are the idea of our new technology to improve etching performance.

Usually, etching proceeds evenly to side wall and to the bottom. In the case of narrow traces, side etching creates a big problem. The width of top circuit cannot be kept due to the side etching. In order to refrain this side etching behavior, special coating on shiny side was thought. If this special coating was not easy to dissolve in the enchant compared to copper, this layer may be able to protect side etching or somehow reduce side etching speed. From now, this special coating is called "EF treatment" which enhances etching performance.

9micron RA foil, 30 micron pitch pattern were used for the etching test to determine the effect of the EF treatment. Surprisingly, the etching factor of EF treatment improved twice compared to that without EF treatment shown in Figure 6. The width of top circuit was almost the same as 10 micron, but the width of the bottom was different. If this sample was etched longer, the top width should be much shorter. This is the reason why the subtractive method has fine line limitation.

a) EF treatment (New technology) b) without EF treatment (Conventional case)

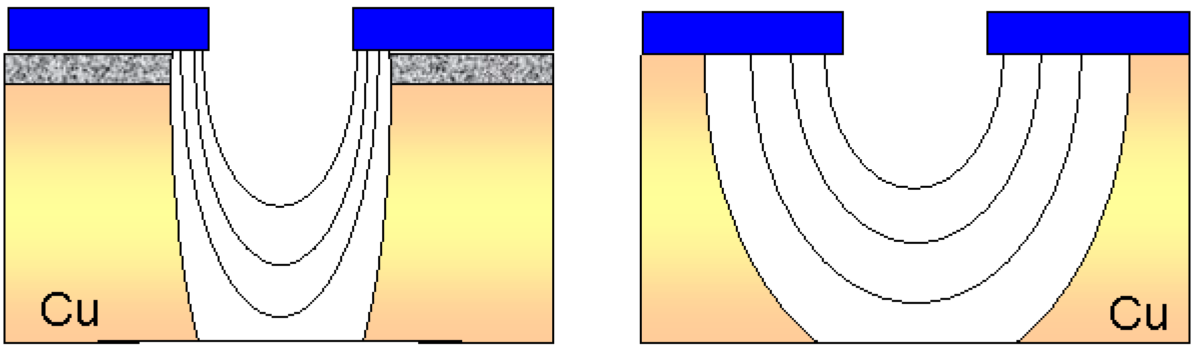
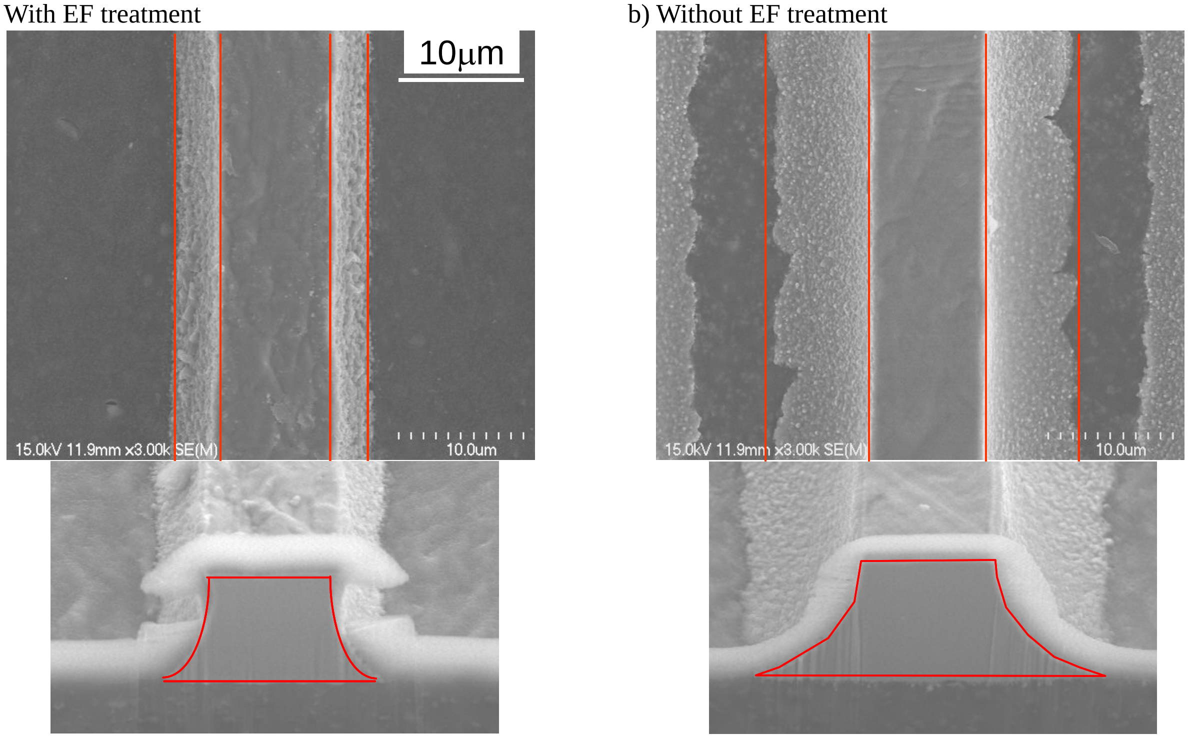


Figure 5 Image of the cross section during etching process.

a) With EF treatment b) Without EF treatment



Etching factor : 2.7
Etching tail length : 3.3 micron

Etching factor : 1.2
Etching tail length : 7.8 micron

Figure 6 The cross sectional observation on the etching test using EF treatment.
(30 micron pitch patterns, 9 micron RA foil were used.)

In Figure 7, comparison was made between 9 micron RA with EF treatment and 9 micron flat type ED. Due to the rougher surface on matte side, some circuit shorted area was found on ED foil, while no irregular was found on RA with EF treatment.

In Figure 8, cross sectional analysis was done to verify the difference between EF treatment and without EF treatment. At the beginning of the etching, the width of the opening did not change at all. However, the difference of the opening width became larger when the etching continued. When etching stopped at almost the middle of the copper foil thickness, there was 6 micron difference between EF and without EF. In addition, overhang at the top edge attached to resist could be found in the case of EF, while there was not overhang on without EF. Thus it was found that EF treatment actually could refrain side etching.

Figure 9 showed the potential of the EF treatment making very narrow traces. Using 18 micron RA, 40 micron pitch trace could be produced by EF treatment, while top width disappeared in the case of ED foil. Even for the thicker foil, still narrower traces can be made using EF treatment.

In addition, Figure 10 showed the result of EF using COF material, which was 2 layer sputtering type FCCL. EF treatment could improve etching factor almost triple compared to that without EF. Using EF treatment, it could be assumed that it may be able to make narrower trace less than 30 micron pitch using regular subtractive method.

a) With EF treatment on 9 micron RA

b) Without EF treatment on 9 micron flat type ED

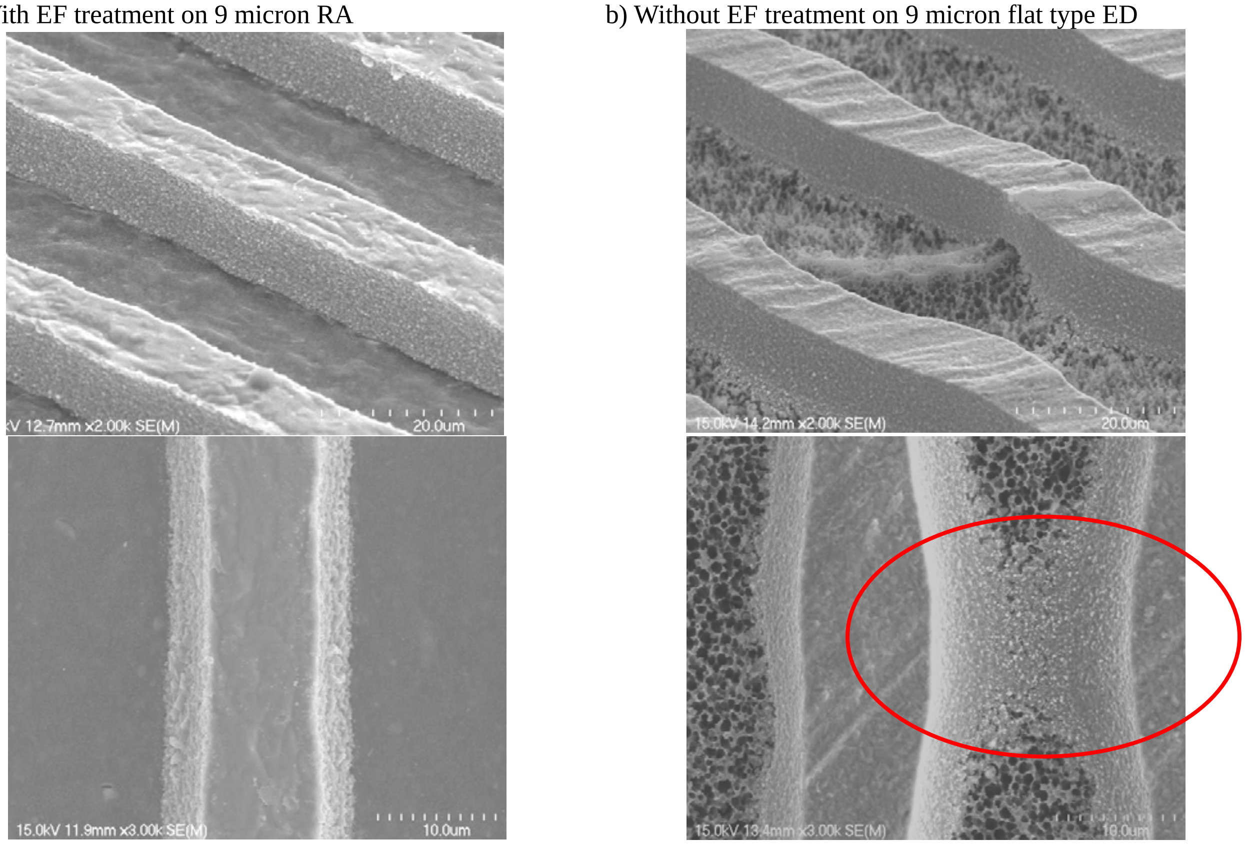


Figure 7 the comparison between RA with EF treatment and flat type ED without EF treatment.
(30 micron pitch pattern, 9 micron copper foils were used. Red circle marked circuit short area.)

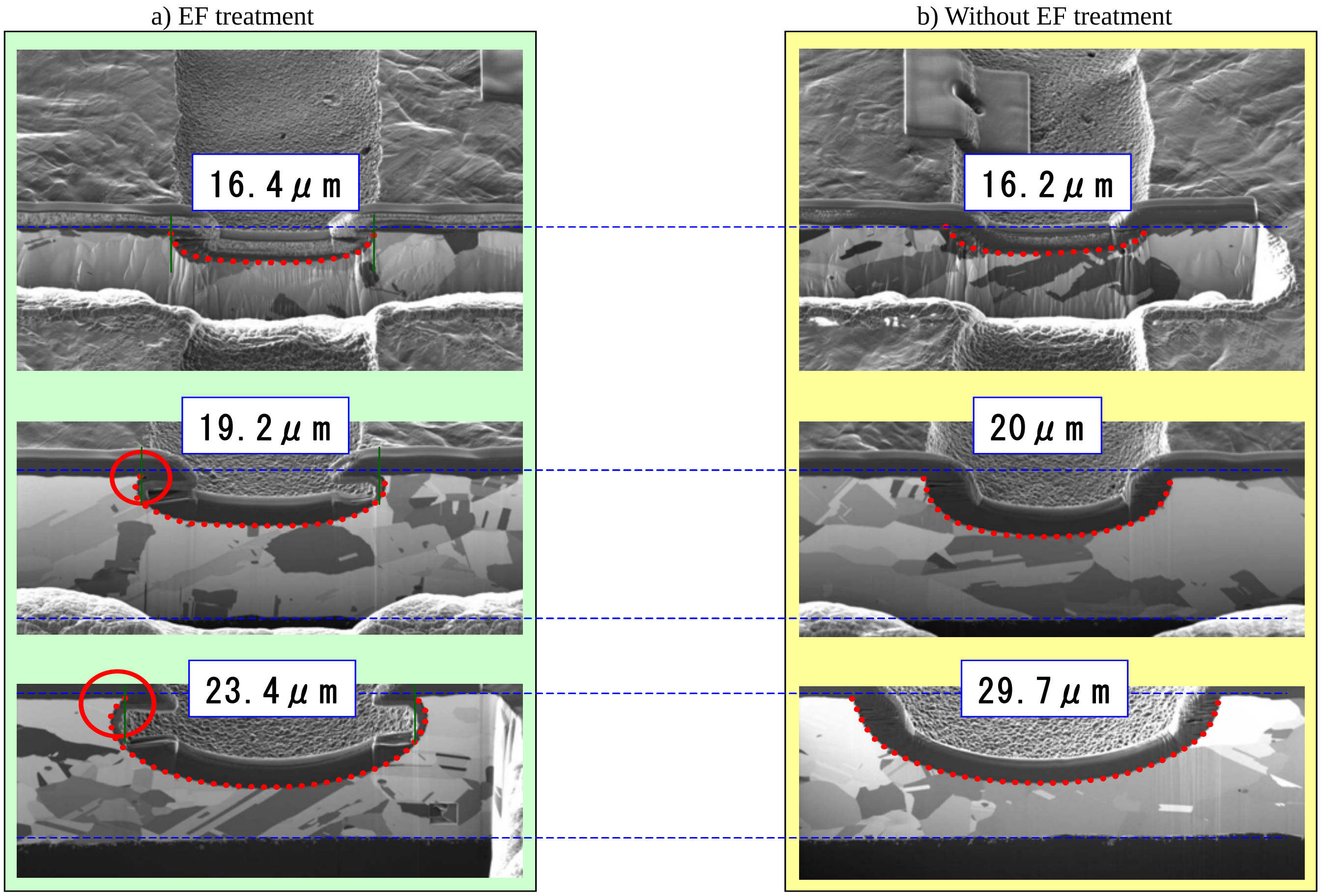


Figure 8 the cross section analysis to compare between EF treatment and without EF treatment on RA during etching process. (30 micron pitch pattern, 9 micron copper foil was used.)

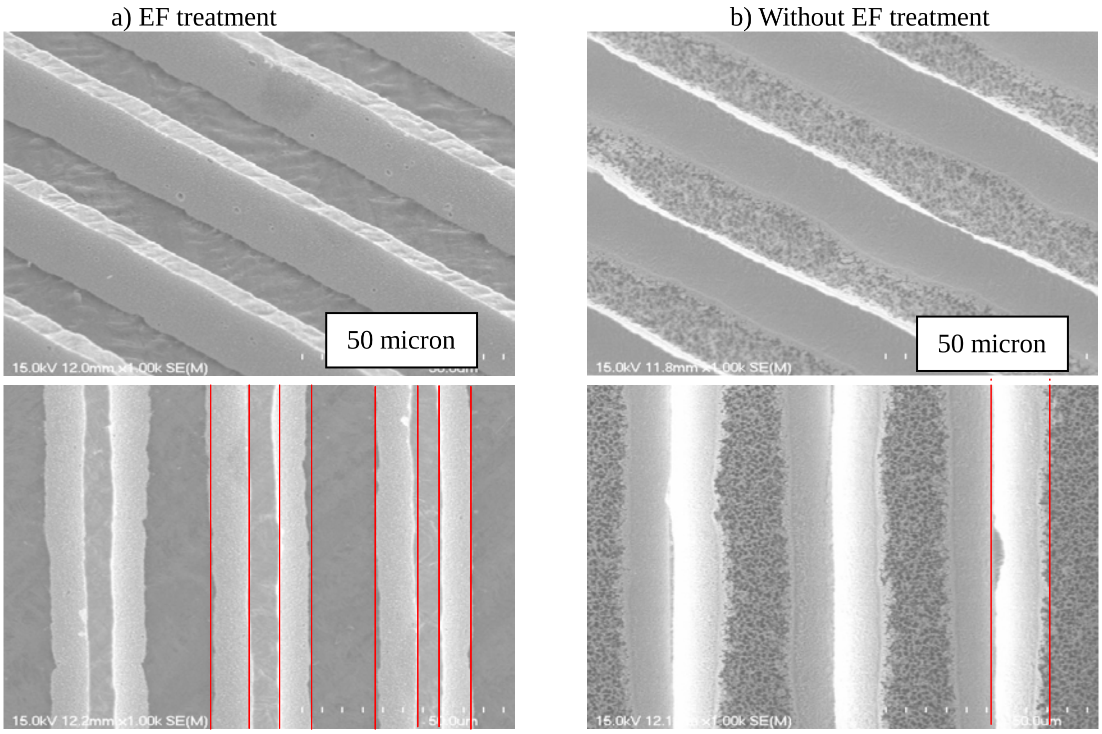


Figure 9 The comparison between RA with EF treatment and flat type ED without EF treatment. (40 micron pitch pattern, 18 micron copper foil were used)

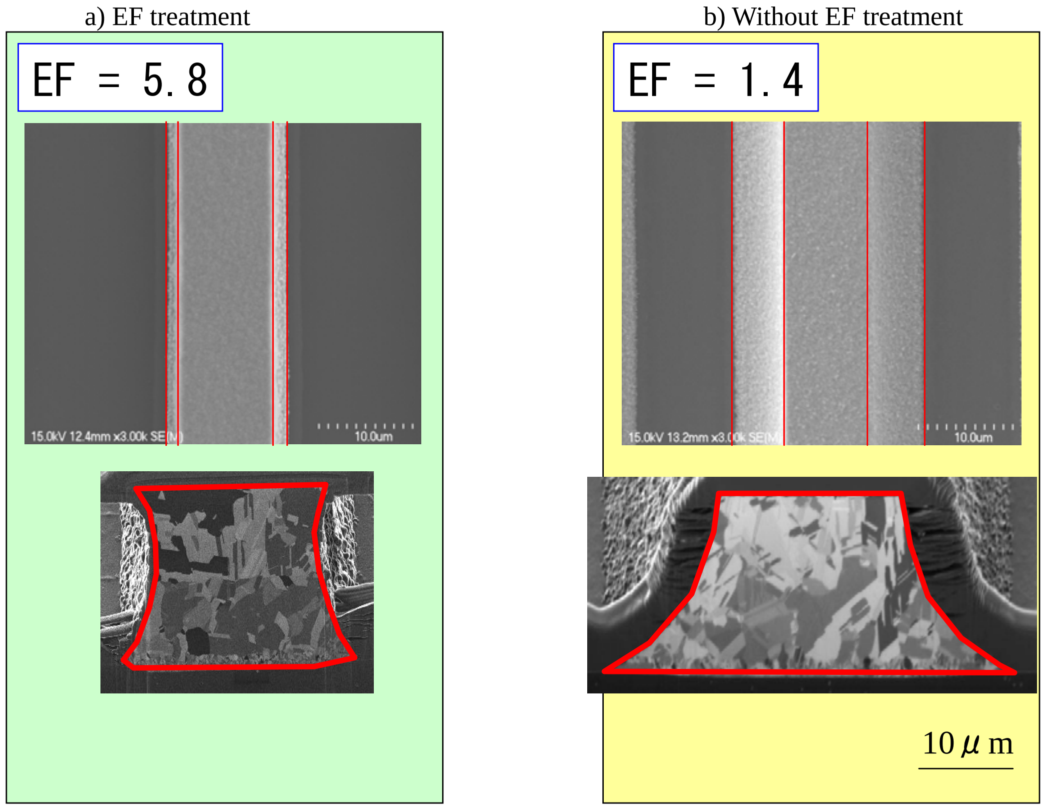


Figure 10 the comparison between EF and without EF treatment on 2 layer sputtering type FCCL. (30 micron pitch pattern, 8 micron copper thickness)

In Figure 11, our latest surface treatment for shiny side was “Cliff treatment”. The Cliff treatment was laboratory base made using vacuum metallization process. The element used for the treatment was different from the EF treatment. Both elements were not easy to dissolve in etchant compared to copper. It was very interesting that the Cliff treatment could improve etching factor much more compared to that of EF. Without EF treatment, etching factor was 1.6 for EF foil. In the case of EF treatment on RA foil, etching factor was 3.3 similar to the previous results. On the other hand, surprisingly, etching factor of the Cliff treatment was 7.2.

Thus, it was found the possibility to improve etching performance by shiny side surface treatment.

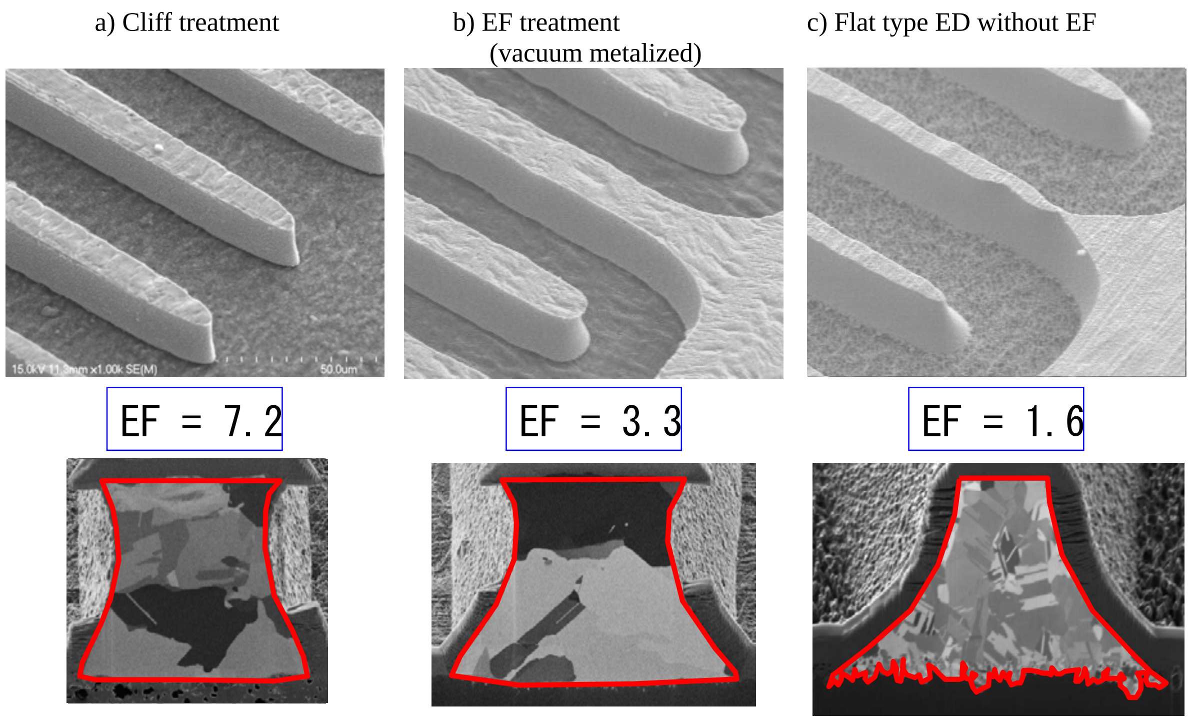


Figure 11 the comparison among Cliff treatment, EF treatment on RA foil and flat type ED without EF treatment. (30 micron pitch pattern, 9 micron copper foil was used)

Conclusion

Recent high-end electronic products need the printed circuit board with HDI. For instance, cellular phone is going to have multi-function in the same size. Flat panel display is going to become much more high density type which needs more circuit traces in the same space. Thus circuits seem to be much narrower than before. Now we are facing the limitation using conventional subtractive etching method. In this paper, new etching technology, EF treatment was introduced and showed its possibility to overcome the limitation. EF treatment is ready to supply samples to customer, and more trials is to be completed for the Cliff treatment.