Quality control of copper plating for coupler

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1. Copper plating on coupler

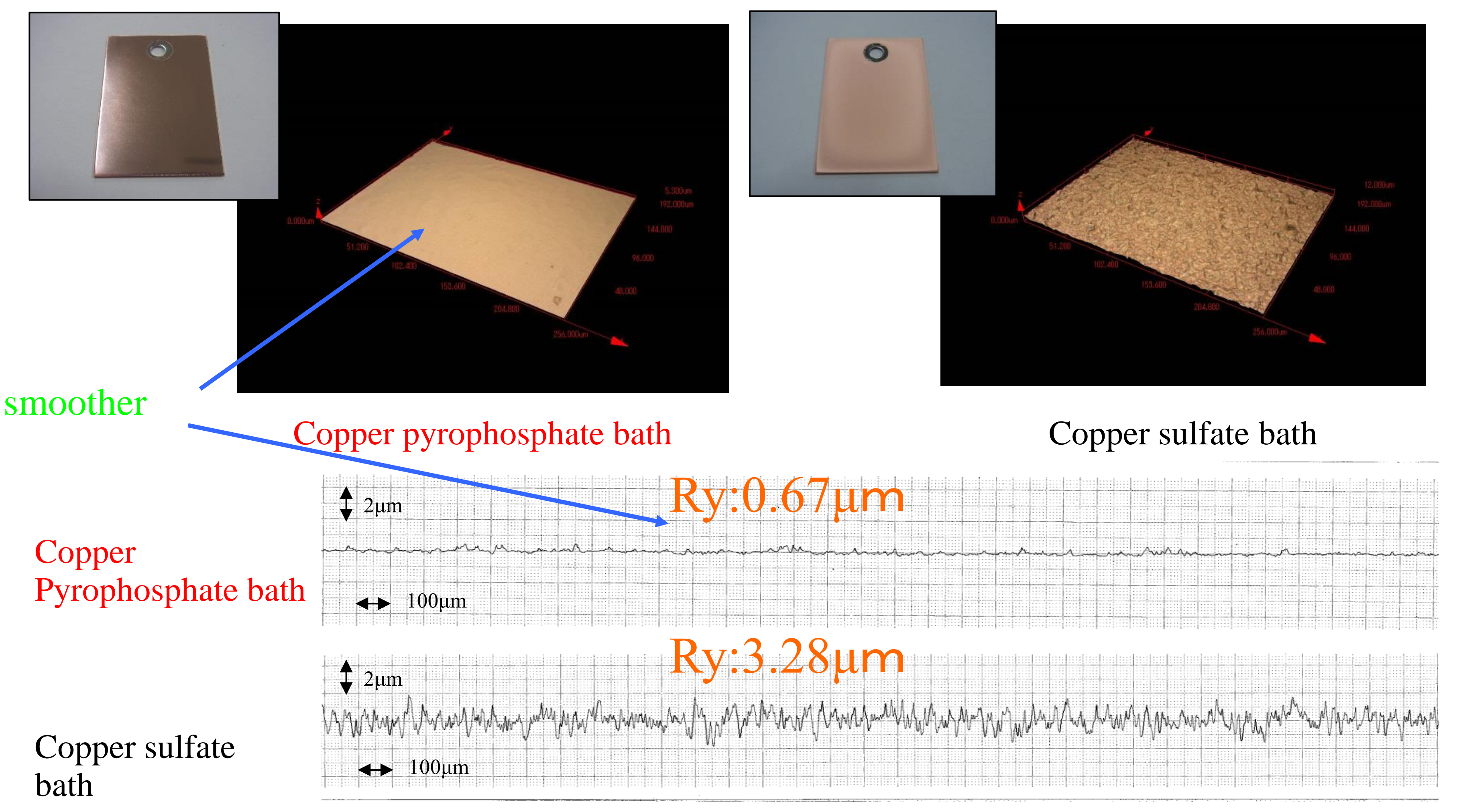
1.1 Selection of copper plating bath

We have performed a comparison study among copper cyanide, copper sulfate, and copper pyrophosphate bathes.

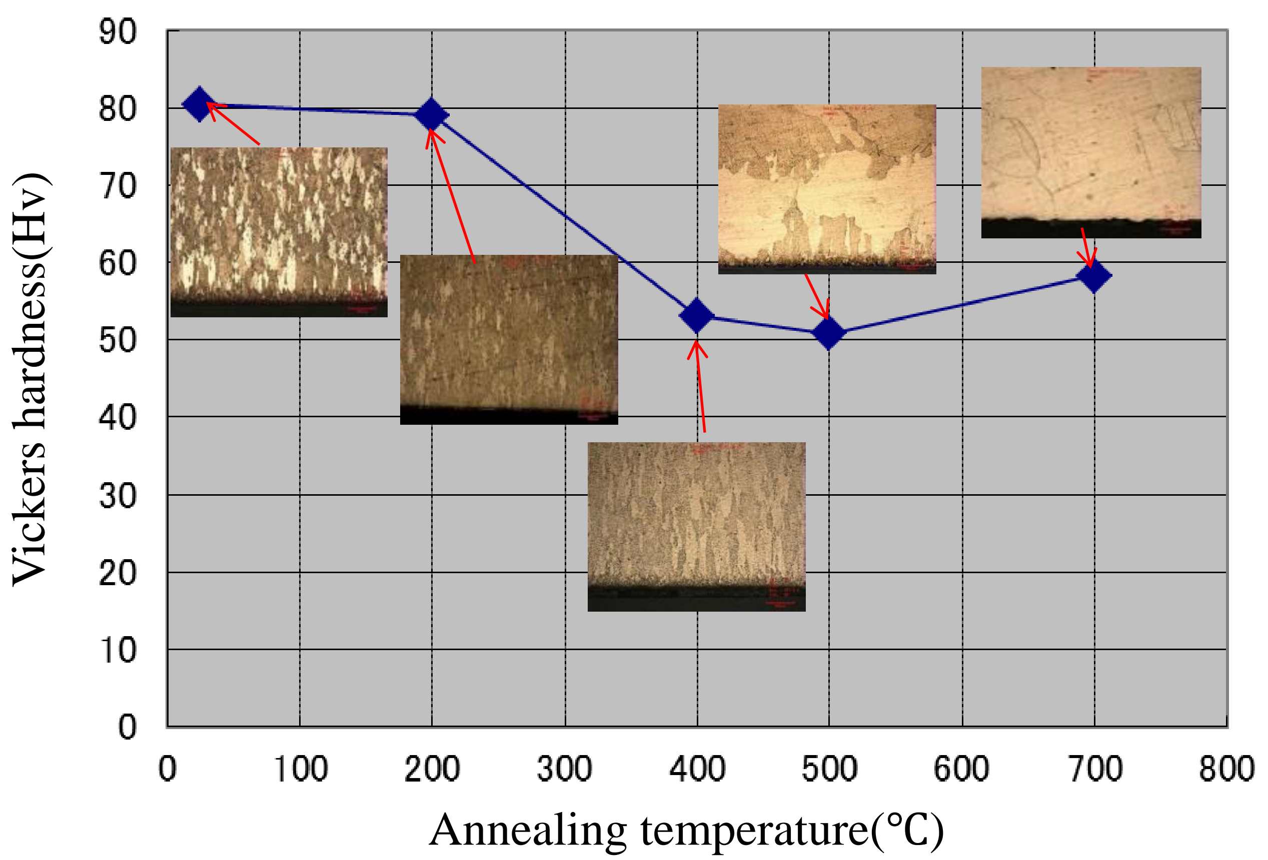
Type of plating bath	Results
Copper cyanide bath	Smoothness was bad, Poison ✕
Copper sulfate bath	Physical property was good. ○
Copper pyrophosphate bath	Physical property was good. ○

1.2 Surface roughness of copper coating

Those figures show surface observation by laser microscope and profiles of the coating roughness by profilometer after copper plating. Copper pyrophosphate plating has smoother surface than sulfate plating.

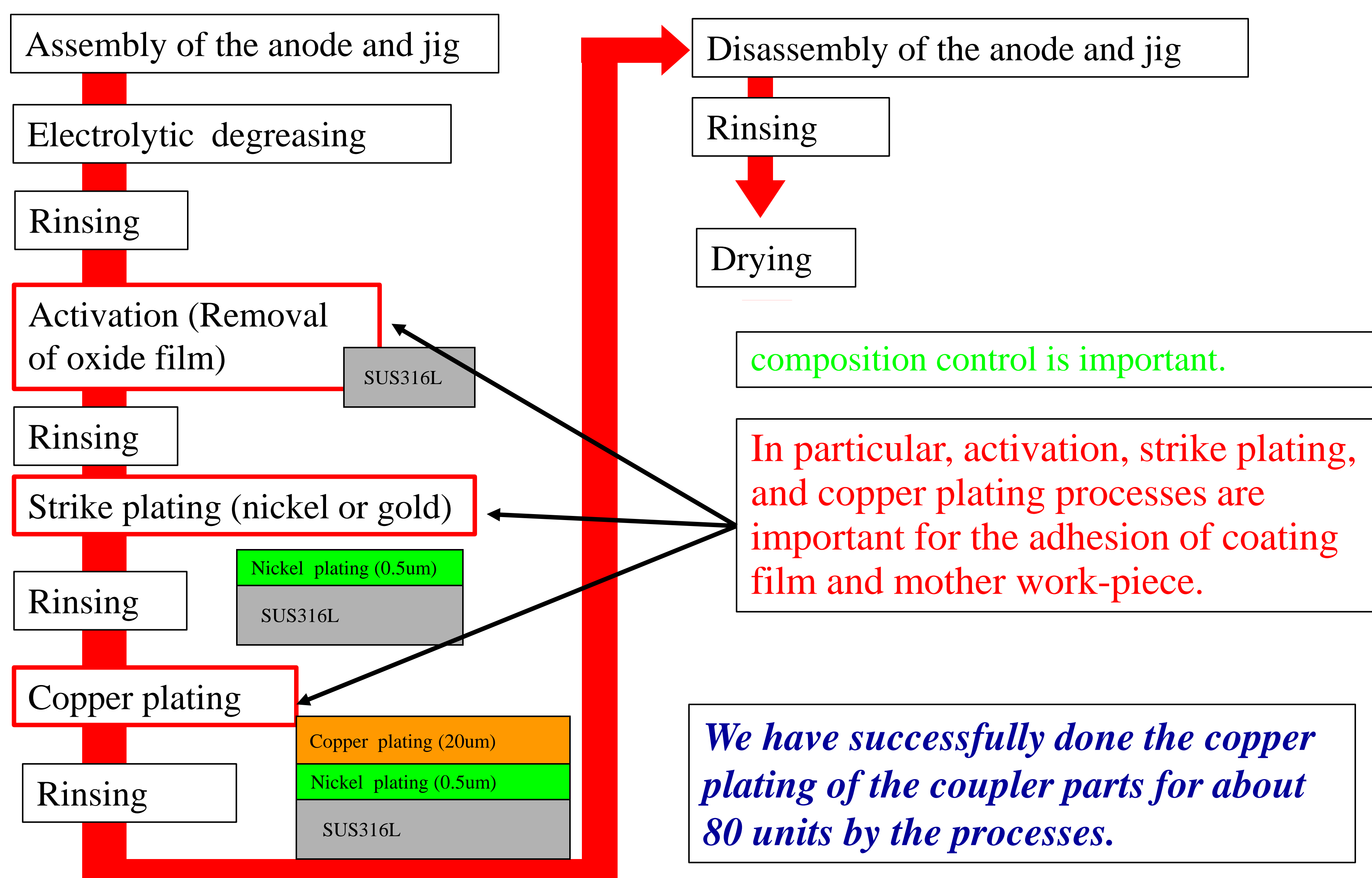


1.3 Grain structure and hardness of copper coating after annealing

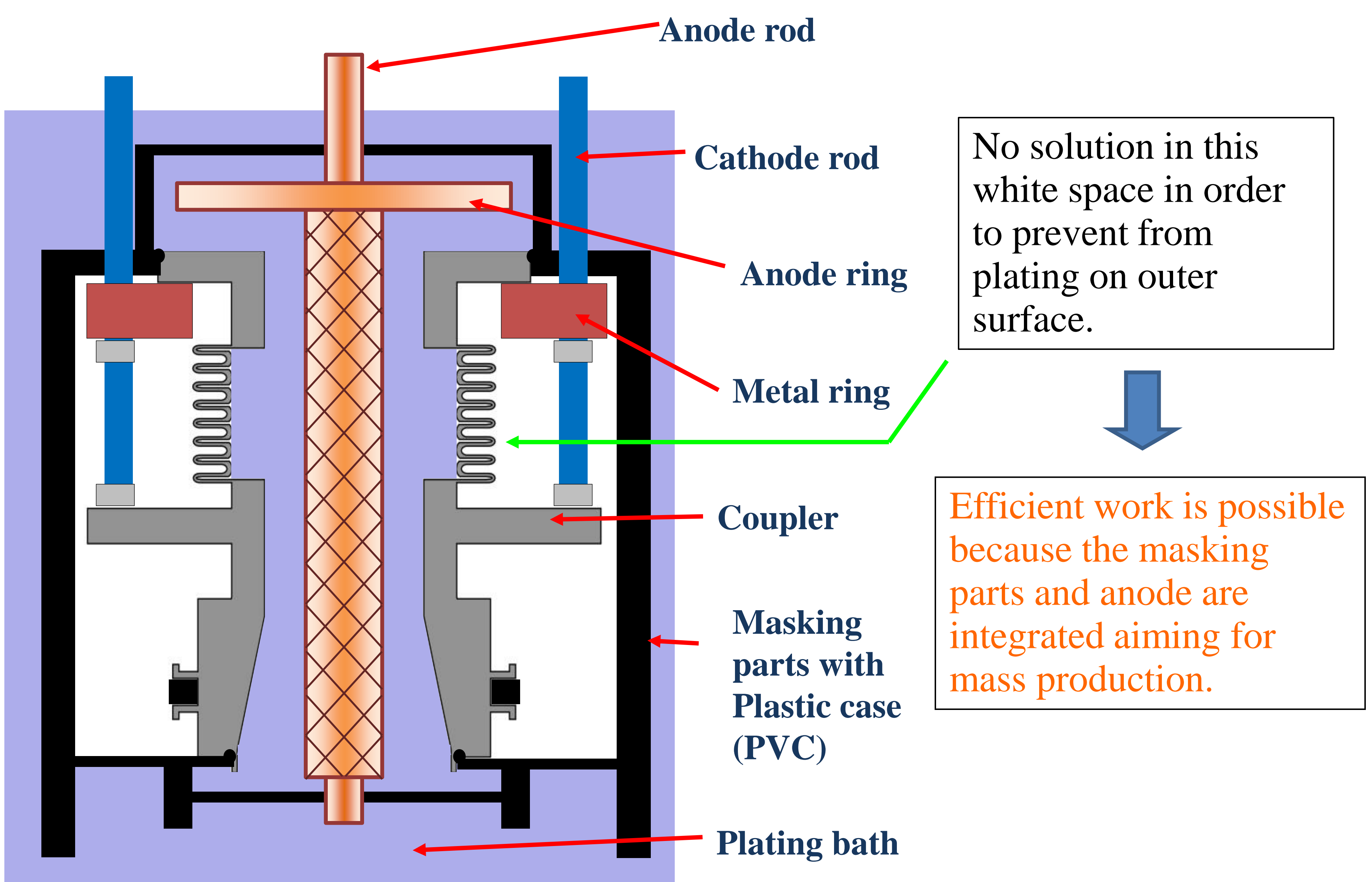


This figure shows a cross-section micro grain structure and hardness of the copper coating from pyrophosphate bath after annealing at various temperatures. The grain size grows with increasing temperature. This is consistent with changes in hardness.

1.4 Copper plating processes for coupler



1.5 Masking technique for coupler



2. Failure report 1

Photo : courtesy of Toshiba Electron Tubes and Devices Co., Ltd.

After the brazing process (conditions: hydrogen furnace, 800 ℃), we found micro-projections on the surface of copper plated parts.

2.1 Occurrence of micro-projection of copper

Part	A	B	C	D
	Cold	Cold	Warm	Warm
	Inner conductor	Outer conductor	Inner conductor	Outer conductor
Plating place	Outside	Inside	Outside	Inside
Strike plating	Nickel	Gold	Nickel	Nickel
Surface status	micro-projections	smooth	micro-projections	micro-projections

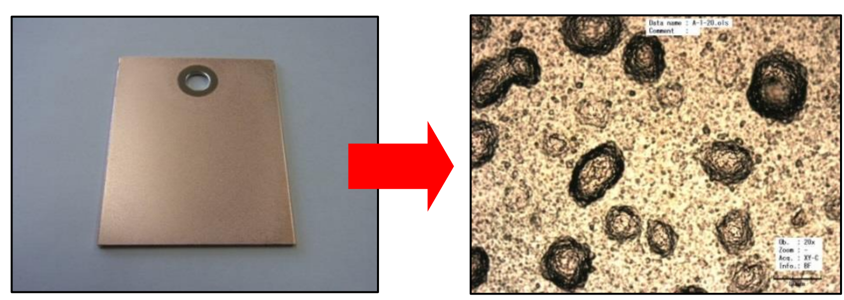
Photos：courtesy of Toshiba Electron Tubes and Devices Co., Ltd.

Micro-projections were created if using nickel for strike plating. On the other hand, smooth surface was obtained if using gold for strike plating.

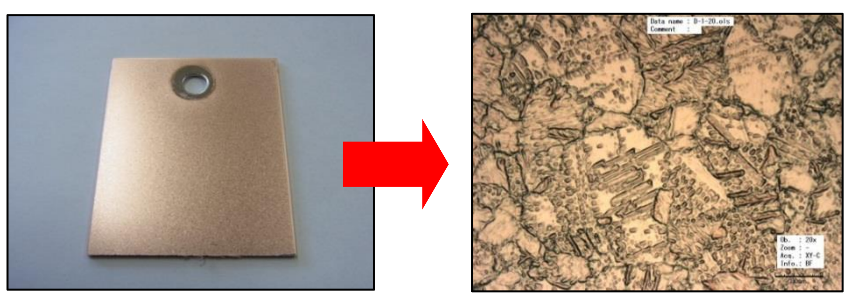
2.2 Result of verification experiment

We thought the reason why we had micro-projections on the copper plated surface might be the old solutions in the plating processes. So we performed verification experiment by old and new solutions in the plating processes.

Conditions	1	2	3	4	5
Solution of nickel strike	old	new	old	new	—
Solution of gold strike	—	—	—	—	old
Solution of copper plating	old	old	new	new	old
Surface status	micro-projections	micro-projections	smooth	smooth	smooth

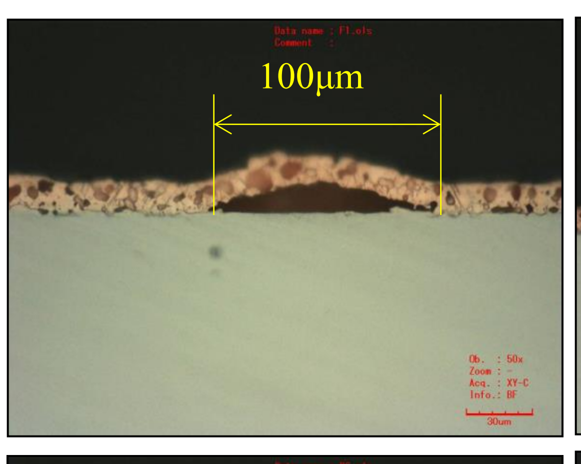


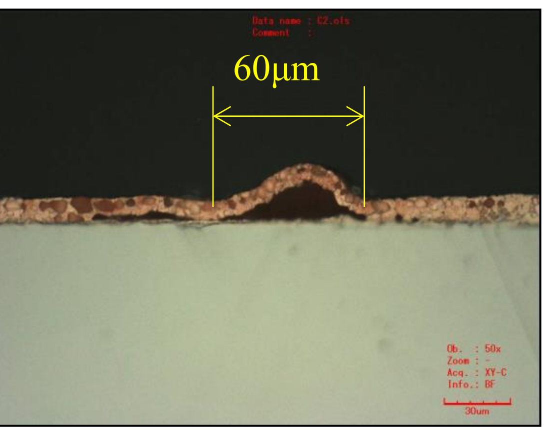
Test piece with micro-projections

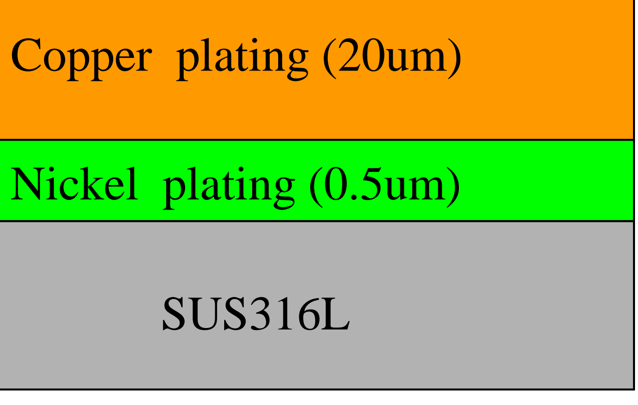


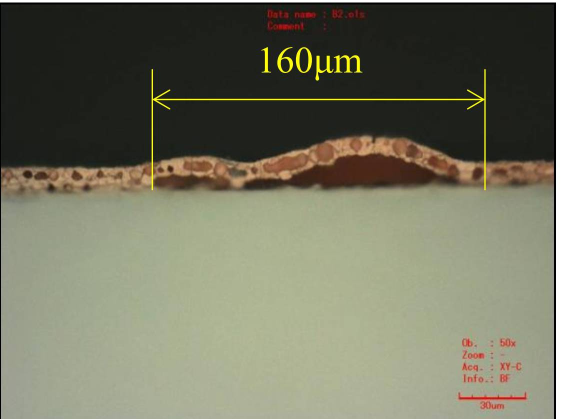
Test piece with smooth surface

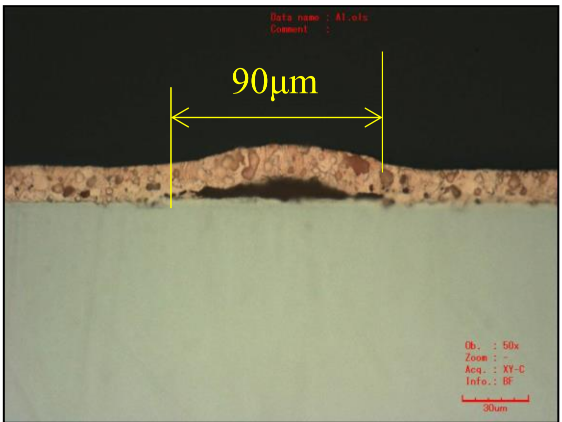
2.3 Cross-section of micro-projection site



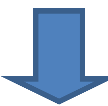








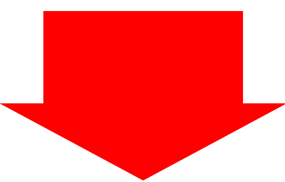
This figure is cross-section model of plating to sus316L



Detachment was found in between copper and nickel films. This means there might be a problem in the solution of copper plating.

2.4 Pollution of copper plating bath, and resolution

We performed the analysis of Organic impurities (Total Organic Carbon = TOC). As the result, we found 100 times more organic carbon contamination in the old solution than new one.



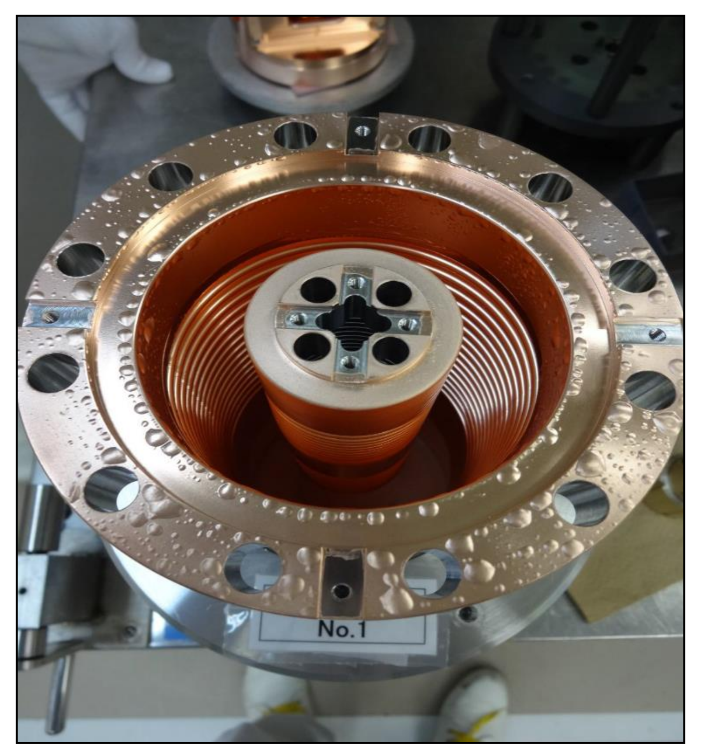
- Organic impurities caused degradation of copper plating bath.
- We have solved this problem successfully with new copper plating bath, or by gold strike plating.

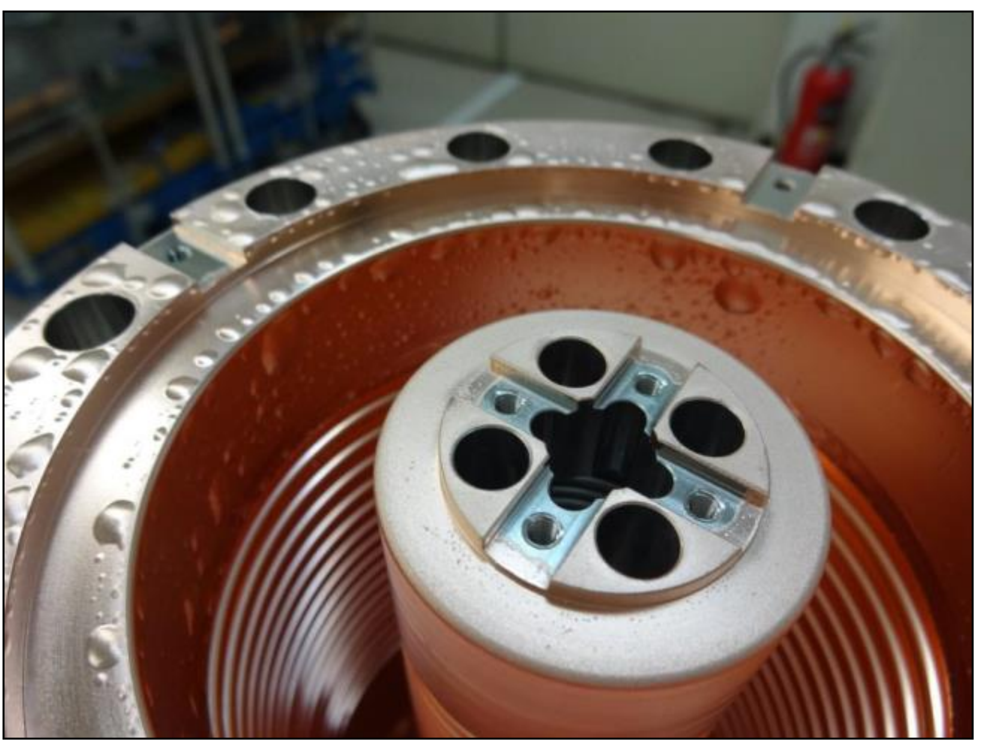
3. Failure report 2

Photo : courtesy of Toshiba Electron Tubes and Devices Co., Ltd.

After the brazing process (conditions: hydrogen furnace, 800 ℃), we found large size of swelling on the surface of copper plated parts.

3.1 Swellings found for copper plating with gold strike after annealing





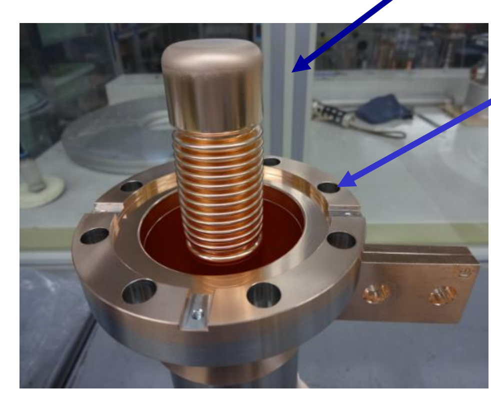
Photos：courtesy of Toshiba Electron Tubes and Devices Co., Ltd.

5 ~ 10mmφ swellings were created only if using gold for strike plating.
Swellings were found mainly around the flange.

3.2 Swellings

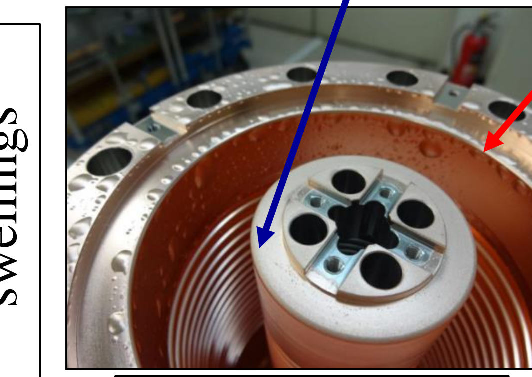
Part	A	B	C	D
	Cold	Cold	Warm	Warm
	Inner conductor	Outer conductor	Inner conductor	Outer conductor
Plating place	Outside	Inside	Outside	Inside
Surface status	smooth	smooth	smooth	Swellings

smooth



Parts A and B

swellings



Parts C and D

Photos : courtesy of Toshiba Electron Tubes and Devices Co., Ltd.

Swellings were found only on the part D.

3.3 Result of verification experiment

Part	A	B	C	D
	Cold	Cold	Warm	Warm
	Inner conductor	Outer conductor	Inner conductor	Outer conductor
Plating place	Outside	Inside	Outside	Inside
Plating area (cm^2)	290	400	430	1200
Strike plating	Gold			
Amount of liquid strike(L)	10			20
Liquid load(Current/L)	1.5	2.0	2.2	3.0
Surface status	smooth	smooth	smooth	Swellings

The part D has the large plating area and large liquid load in the plating process, and we used gold for strike plating to the part D.

We have solved this problem by applying the nickel strike plating only to part D.

We are also investigating the reason why swellings were created in the current conditions of gold strike plating.

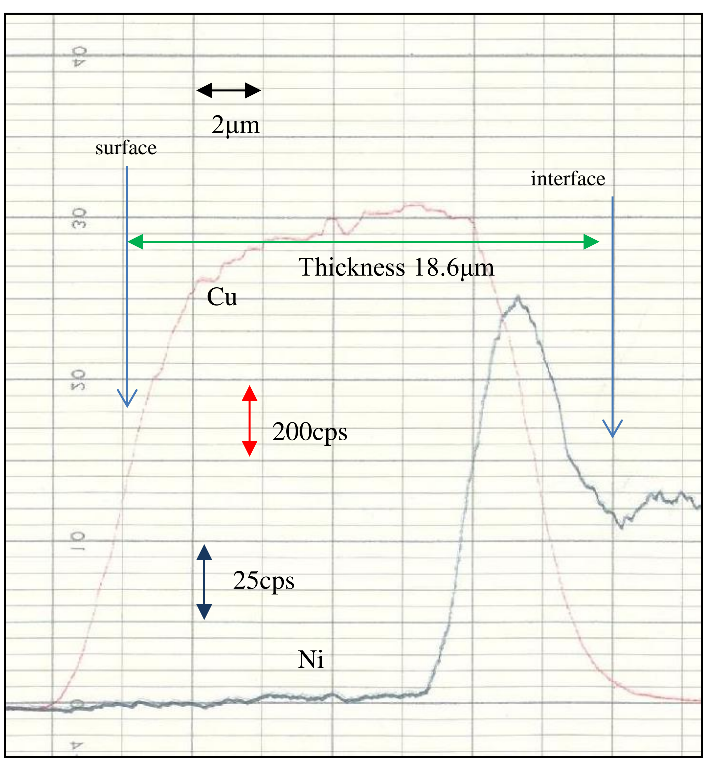
4. References: Difference between gold strike and nickel strike

Diffusion of metal after strike plating

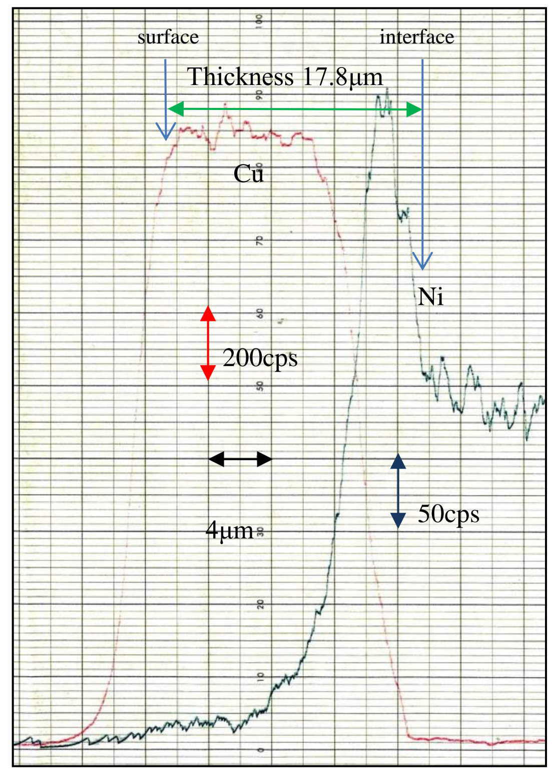
4.1 Diffusion of strike nickel plating

Strike nickel plating film is diffused into the copper coating in the brazing process (conditions: hydrogen furnace, 800 ℃,10min), but strike nickel plating was remained sufficiently near interface between work and copper coating.

Before annealing



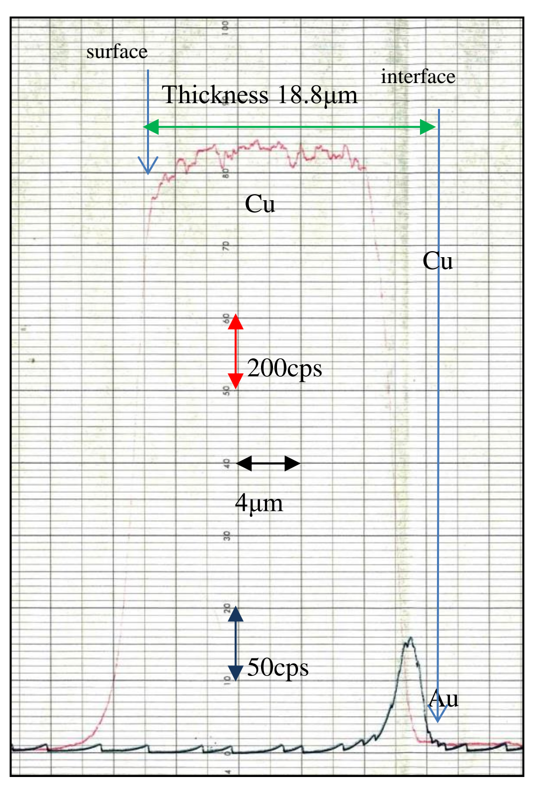
After annealing



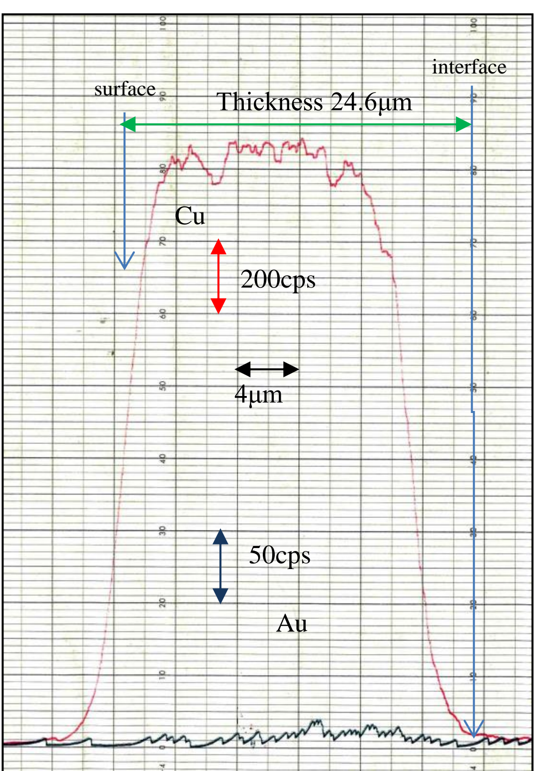
4.2 Diffusion of strike gold plating

Strike gold plating film is diffused into whole of copper coating in the brazing process (conditions: hydrogen furnace, 800 °C,10min), strike gold plating film was not remained sufficiently near interface between work and copper coating.

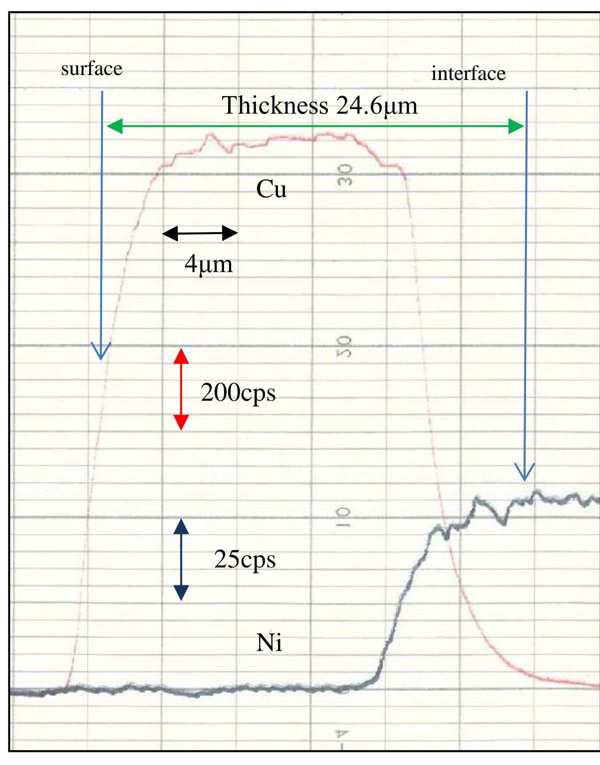
Before annealing



After annealing



Reference : Nickel



4.3 Results of dissolved copper plating using nitric acid

Before annealing at 800°C

Before dissolve → After dissolve

After annealing at 800°C

Before dissolve → After dissolve

After dissolving the copper coating by nitric acid, we measured strike gold film at surface by EPMA.

Gold did not be confirmed

But all copper coatings adhered on test-piece by doing bending test.

Conclusion

1) The copper pyrophosphate bath is suitable for plating to coupler parts.

2) The usage of old solution caused micro-projections.
We have solved this problem with new solution, or by gold strike plating.

3) A part with large plating area and large liquid load in the gold strike plating had swellings. We have solved this problem by applying the nickel strike plating.

4) After brazing at 800°C by hydrogen furnace, strike gold film diffused into the copper coating. But all copper coatings adhered on test-piece by doing bending test.

End