Plating Specification for ALMA Band 6 Components

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This note describes the appropriate types of plating for some common NRAO and ALMA components, and gives details of how gold plating should be specified under the new standard ASTM B 488 - 01 (2006) which replaces the obsolete MIL-G-45204. This updates an earlier document by G. Morris (15 August 2006).

ASTM B 488 - 01 (2006) for gold plating contains several sub-classifications which must be specified:

(i) TYPE specifies the purity of the plating:

Type I	99.7%
Type II	99.0%
Type III	99.9%

Note that the order is not simply increasing purity – this was done to conform to the older MIL spec.

(ii) CODE specifies the Knoop hardness of the plating:

Code A	$\leq 90\ KH_{25}$
Code B	$91 - 129\ KH_{25}$
Code C	$130 - 200\ KH_{25}$
Code D	$> 200\ KH_{25}$

Note that the CODE in the ASTM spec. corresponds to GRADE in the old MIL spec.

(iii) CLASS specifies the minimum plating thickness in microns:

Class 0.25	0.25 microns	(10 micro-inches)
Class 0.50	0.50 microns	(20 micro-inches)
Class 0.75	0.75 microns	(30 micro-inches)
Class 1.0	1.0 microns	(40 micro-inches)
Class 1.25	1.25 microns	(50 micro-inches)
Class 2.5	2.5 microns	(100 micro-inches)
Class 5.0	5.0 microns	(200 micro-inches)

(iv) UNDERPLATING with nickel is the default for parts made of copper or copper alloys. Normally at least 1 micron (40 micro-inches) of nickel is used as a diffusion barrier, to reduce overall porosity, and to produce a brighter surface. The standard notes that the underplating can be omitted in cases such as waveguides in which the nickel may increase the electrical loss.

Specifying Gold Plating per ASTM B 488 - 01 (2006) requires that the plater be given the above parameters and also details of any testing to be done on the plating (see the standard for particulars).

Not all combinations of Code (hardness) and Type (purity) are possible. According to ASTM B 488 - 01 (2006), the following combinations are considered representative of good commercial practice:

Purity	Type	Hardness	Code
99.9%	III	$\leq$ 90 HK_{25}	A
99.7%	I	$\leq$ 200 HK_{25}	A, B, C
99.0%	II	> 90 HK_{25}	B, C, D

Note that high purity Type-III gold is not listed in combination with the higher hardness Codes B, C, or D. However, the bright gold used at NRAO, Enthone BDT 200, is specified by the manufacturer as having a purity of 99.9% (*i.e.*, Type III) with a hardness of 130-200 (*i.e.*, Code C). Enthone says that BDT 200 does in fact achieve plating of the claimed purity and hardness, although it may not be as pure as that of some other Type III baths nor as hard as that of other Code C baths. Alexandria Metal Finishers, however, stated that if high purity Type III gold was needed, they could only obtain hardness Code A ($\leq$ 90).

Recommendations for NRAO and ALMA gold plating

Amplifier bodies (brass)	ASTM B 488-01 (2006) Type III, Code A, Class 7.5 , with no nickel underplating. (Soft gold, 99.9%, $\leq$ 90 KH_{25}, 300 micro-inches, no Ni.)
Amplifier lids (brass)	ASTM B 488-01 (2006) Type I, Code C, Class 2.5 , with no nickel underplating. (Bright gold, 99.7%, 130 - 200 KH_{25}, 100 micro-inches, no Ni.)
Mixer blocks (brass)	ASTM B 488-01 (2006) Type I, Code C, Class 1.5 , with no nickel underplating. (Bright gold, 99.7%, 130 - 200 KH_{25}, 50 micro-inches, no Ni.)
Heat straps (annealed copper)	ASTM B 488-01 (2006) Type III, Code A, Class 2.5 , with no nickel underplating. (Soft gold, 99.9%, $\leq$ 90 KH_{25}, 100 micro-inches, no Ni.)
Misc. brackets (brass or copper)	ASTM B 488-01 (2006) Type I, Code C, Class 2.5 , with no nickel underplating. (Bright gold, 99.7%, 130 - 200 KH_{25}, 100 micro-inches, no Ni.)

Gold Plating of Aluminum

Aluminum may be used for electronic components when weight is of concern. If it is desired to gold plate the aluminum, a substantial nickel under-layer is used. For the ALMA Warm Multiplier Assemblies, which are made of 6061-T6 aluminum, a 50 - 90 micro-inch electroless nickel underplate is followed by 50 - 75 micro-inches of bright gold (not to exceed 200 micro-inches), with no bake required. This corresponds to specifying either:

(a) ASTM B 488-01 (2006), Type I, Code C, Class 1.25, not to exceed 5 microns, with a 1.27-2.29 micron electroless nickel underplate, no bake required.

or (b) ASTM B 488-01 (2006), Type II, Code C, Class 1.25, not to exceed 5 microns, with a 1.27-2.29 micron electroless nickel underplate, no bake required.

or (c) ASTM B 488-01 (2006), Type II, Code D, Class 1.25, not to exceed 5 microns, with a 1.27-2.29 micron electroless nickel underplate, no bake required.

Of these, (a) has the more pure gold while (c) is the hardest.

Copper Plating Inside Stainless Steel Waveguides

To reduce the loss of stainless steel waveguides, the inside can be plated with copper. For stainless steel WR-10 waveguide, 50 micro-inches (1.25 microns) of copper has been found to reduce the loss to about that of coin silver waveguide while showing no effects of atmospheric corrosion in over twenty years exposure. This thickness is about 5 skin depths at 100 GHz. The copper is plated from an acid solution – details are given in a separate report [1].

Acknowledgments

These notes are a revision of an earlier document by G. Morris (15 August 2006), and resulted from a discussion between J. Effland, G. Morris, G. Petencin, and A. Kerr (11 April 2007), with additional information from Eric Bryerton (NRAO), Jeannette French at Alexandria Metal Finishers, and Mike Lynch at Enthone.

References

[1] G. Petencin, "Plating the Inside of Stainless Steel Waveguide to Reduce RF Losses While Retaining the Thermal Isolation," ALMA DOC FEND-40.02.06.00-140-A-PRO, National Radio Astronomy Observatory, July 14, 2005.
http://www.cv.nrao.edu/~akerr/PlatingStainlessSteelWaveguide-V7.pdf