Attenuation in EDM'd Waveguide

Marc Hill

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Abstract

The attenuation of an EDM'd copper waveguide was measured and compared with the attenuation in a commercial piece of Aerowave waveguide. Previous results were presented in [1]. The new data, presented here, will be used to compare the piece of rough cut waveguide before and after being chemically treated. The data will show that chemical cleaning had negligible effect, however the chemical polishing made a significant improvement.

1 Introduction

Measurements of attenuation in Aerowave and EDM'd waveguide were presented in [1] using the group's W-band vector network analyzer described in [2]. More data were taken using the network analyzer to study the effects of chemical cleaning (CC) and chemical polishing (CP) on surface losses. The data were taken using the "rough cut" piece of waveguide described in [1].

2 Chemical Treating

The same piece of EDM'd waveguide was used in both of these studies. The CC process was intended to remove any contaminates and should not have caused any etching of the metal. We believe that no etching occurred; however there was no check of this assumption. The CC was performed by Ali Farvid and the process is described in "Process Specification C01c" in the appendix. All steps were taken in the sequence except for step 9.

The CP process was also performed by Ali Farvid. This process was intended to remove several microns of copper from the surface. Again, we assumed such, but there is no confirmation. The process is described in "Process Specification C1" this time omitting steps 8 & 11.

3 Results

Data of transmitted power were taken for three scenarios: 1. no waveguide, 2. a 2" piece of Aerowave waveguide and 3. the 2" EDM'd rough cut waveguide. The raw data are plotted in Figures 1 and 2.

The attenuation was then calculated by subtracting the power transmitted through the waveguides from the power transmitted with no waveguide. These results are plotted in Figure 3 and summarized in Table 1, including the theoretical value from [2].

CP EDM Waveguide	-.16 dB
Aerowave Waveguide (5 aug 97)	-.26 dB
Aerowave Waveguide (12 sep 97)	-.25 dB
CC EDM Waveguide	-.44 dB
OFE Cu (theoretical)	-.13 dB

Table 1: Average Attenuation

4 Conclusion

The CC process showed negligible difference, however the CP process gave a surprisingly large improvement. A measurement of the surface roughness should be done to compare surface finish with wall Q. When comparing with the results of [1], the CP'd "rough" cut waveguide has lower attenuation than the "fine" cut waveguide.

Whether similar improvements can be obtained in a more complicated structure, *i.e.* a muffin tin, must still be determined.

References

[1] P. Chou & R. Siemann, ARDB note 99

[2] R. Siemann, ARDB note 45

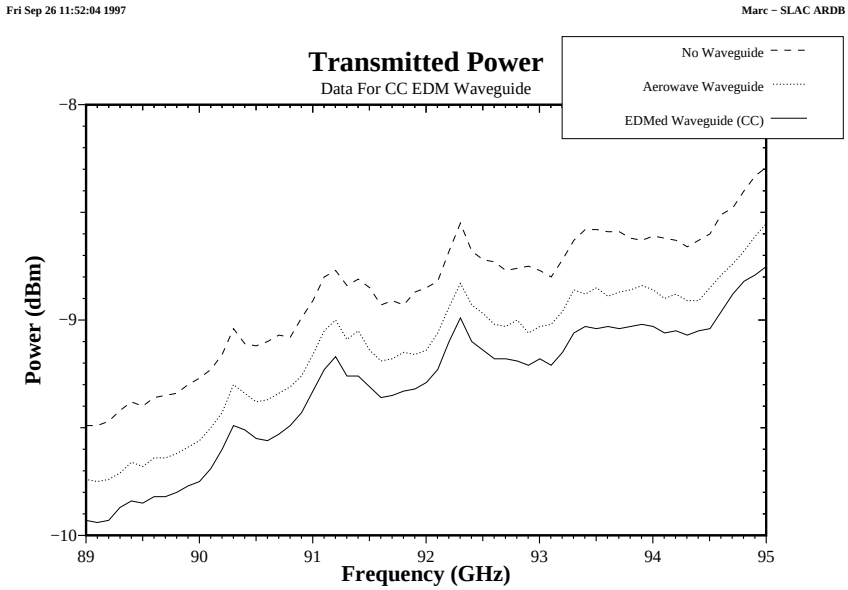

Figure 1: Raw Data for Aerowave and CC EDM Waveguide

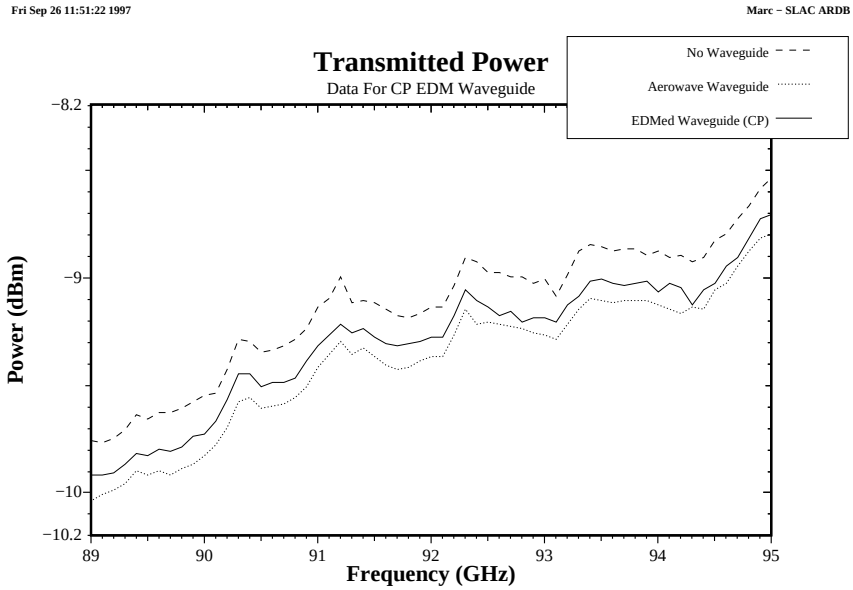

Figure 2: Raw Data for Aerowave and CP EDM Waveguide

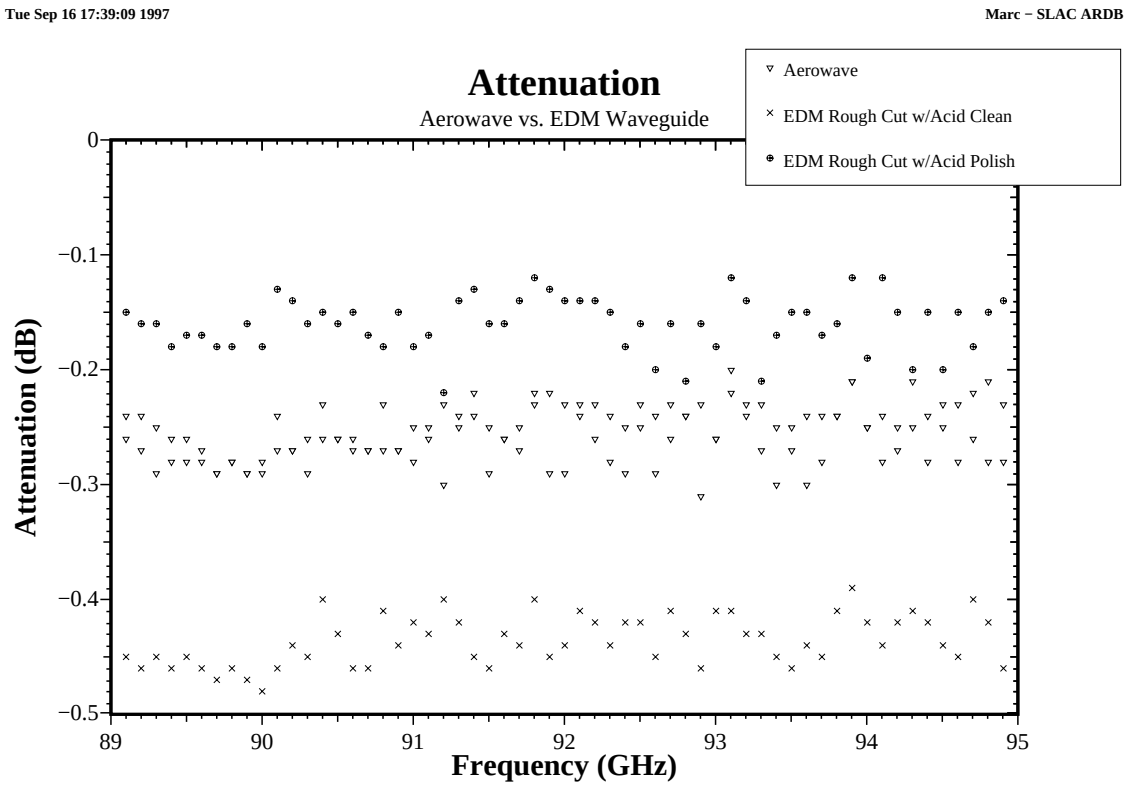

Figure 3: Waveguide Attenuation

A Chemical Cleaning

MFD Manual on the process colloquially known as "Chem Clean," officially known as Process Specification C01c. [Transcribed by David Whittum]

MFD Metal Finishing Process Specifications

Dated 9 July 1997
No. 07-03-04-00
Process Specification C01c

Chemical Cleaning of Oxygen Free Electronic Grade Copper

Date	1/19/89
Prepared by	K. Narula
Checked by	A. Farvid

Caution! The chemicals use in this process are solvents, acidic and alkaline. Exercise caution in their use. Do not breathe vapors. Avoid contact with skin, eyes and clothing by using appropriate safety equipment. Provide adequate ventilation.

Carefully read and observe cautionary and first-aid information in MSDSs (Material Safety Data Sheets) and Table I of Hazardous Chemicals Commonly Used in the Metal Finishing Industry (in front of this booklet).

1.0 Scope

- This document describes the chemical cleaning procedure for O.F.E. copper. This process will not remove any copper from the surface.

2.0 Sequence

- Step 1 Vapor degrease in **1,1,1 Trichloroethane** [Ref: Product of Dow Chemical Co.] or equivalent degreaser for five minutes. *Note: to reduce solvent concentration in the breathing zone, the work load/parts should be lowered and removed at a slow speed.*

- Step 2 Alkaline soak clean using **Enbond Q527** [Ref: Product of Enthone, Inc., New Haven, CT] for five minutes at a temperature of 180°F.

- Step 3 Cold tap water rinse for two minutes

- Step 4 Immerse in 10% by volume **Metex 9268** [Ref: product of MacDermid Co., Waterbury, CT] acid solution at room temperature for five minutes.

- Step 5 Cold tap water rinse for two minutes.

- Step 6 Immerse in **Metex 629** (Ref: product of MacDermid Co., Waterbury, CT) acid solution for 30 seconds.
- Step 7 Tap water rinse for one minute.
- Step 8 Deionized water rinse for one minute.
- Step 9 Immerse in a solution of **Oxyban 60** (product of Thiokol/ Dynachem Corp., Tustin CA) for 2-5 minutes.

  [NOTE INSERTED: THIS STEP WAS NOT USED FOR THE EDM'D WAVEGUIDE STUDY]
- Step 10 Cold tap water rinse for one minute.
- Step 11 Cold deionized water rinse for one minute (minimum resistivity of 1,000,000 ohms-cm).
- Step 12 Hot deionized water rinse for thirty seconds (minimum resistivity of 1,000,000 ohms-cm).
- Step 13 Immerse in analytical reagent grade **Isopropyl Alcohol** at 115°F for thirty seconds. *Note: to avoid breathing the vapors, remove parts slowly and drain thoroughly.*
- Step 14 Blow dry with a dry nitrogen blast.
- Step 15 Dry in air oven at 150°F.
- Step 16 Wrap in lint-free paper and aluminum foil.

B Chemical Polishing

MFD Manual on the process colloquially known as "Chem Polish," officially known as Process Specification C1. [Transcribed by David Whittum]

MFD Metal Finishing Process Specifications

Dated 25 January 1996
No. 07-03-04-00
Process Specification C1

Chemical Cleaning of Oxygen Free Electronic Grade Copper

Date	3/31/88
Prepared by	J. Pope
Checked by	A. Farvid (x2580)

Caution! The chemicals use in this process are solvents, acidic and alkaline. Exercise caution in their use. Do not breathe vapors. Avoid contact with skin, eyes and clothing by using appropriate safety equipment. Provide adequate ventilation.

Carefully read and observe cautionary and first-aid information in MSDSs (Material Safety Data Sheets) and Table I of Hazardous Chemicals Commonly Used in the Metal Finishing Industry (in front of this booklet).

1.0 Scope

- This document describes the chemical cleaning procedure for O.F.E. copper for use in vacuum and brazing processes. This process will remove nominal amount of copper from the surface.

2.0 Sequence

- Step 1 Vapor degrease in **1,1,1 Trichloroethane** [Ref: Product of Dow Chemical Co.] or equivalent degreaser for five minutes. *Note: to reduce solvent concentration in the breathing zone, the work load/parts should be lowered and removed at a slow speed.*

  [Note Inserted: 1,1,1 Trichloroethane will at some point in the future no not be used, at it is no longer an approved degreaser.]

- Step 2 Alkaline soak clean in **Enbond Q527** [Ref: Product of Enthone, Inc. New Haven, CT] for 5 minutes at 180°F.

- Step 3 Cold tap water rinse for two minutes.

[Note inserted: A call to MFD confirms that in fact they DO use cold tap water. Al Menegat hopes that they do not let the tap water dry. An unnamed source in MFD hopes likewise.]

- Step 4 Immerse in 50% **Hydrochloric Acid** at room temperature for one minute.

- Step 5 Cold tap water rinse for two minutes.

- Step 6 Immerse in the following solution for maximum of one minute depending on the surface finish required.

Phosphoric Acid, 75%	21 gallons
Nitric Acid, 42° Baumè	7 gallons
Acetic Acid, glacial	2 gallons
Hydrochloric Acid, analytical grade	19.2 fluid ounces
Temperature	Room

[Note inserted: Research by Al Menegat reveals the following. Ref: Websters II, New Riverside Dictionary, Houghton Mifflin, 1984. Baumè Scale (pron. boh-may) After Antoine Baumè (1728-1804) A hydrometer scale that separately covers liquids with specific gravities greater and less than 1.]

[Note inserted: Research by ARDB Technical Research Dept, headed by Al Menegat reveals the following. Ref: ibid.. Glacial acetic acid: acetic acid that is at least 99.8% pure.]

- Step 7 Cold tap water rinse for minimum of two minutes until the film on part disappears.

- Step 8 Immerse in the following solution until the part is covered with white film. (Do not immerse for more than 5 seconds)

Sulfuric Acid, 66° Baumè	13 gallons
Nitric Acid, 43° Baumè	7 gallons
Water	10 gallons
Hydrochloric Acid, 20° Baumè	15 fluid ounces
Temperature	Room

[NOTE INSERTED: THIS STEP WAS NOT USED FOR THE EDM'D WAVEGUIDE STUDY]

- Step 9 Cold tap water rinse for minimum of two minutes until the film on part is disappear (sic).

- Step 10 Cold deionized water rinse for one minute (minimum resistivity of 1,000,000 ohms-cm).

- Step 11 Immerse in a solution of **Oxyban 60** (Ref: product of Thiokol/ Dynachem Corp., Tustin, CA) (1

  [NOTE INSERTED: THIS STEP WAS NOT USED FOR THE EDM'D WAVEGUIDE STUDY]

- Step 12 Cold tap water rinse for one minute.
- Step 13 Cold deionized water rinse for one minute (minimum resistivity of 1,000,000 ohms-cm).
- Step 14 Cold deionized water rinse for one minute (minimum resistivity of 1,000,000 ohms-cm).
- Step 15 Hot deionized water rinse for thirty seconds (minimum resistivity of 1,000,000 ohms-cm).
- Step 16 Immerse in analytical reagent grade **Isopropyl Alcohol** at 115°F for thirty seconds. *Note: to avoid breathing the vapors, remove the parts slowly and drain thoroughly.*
- Step 17 Blow dry with a dry nitrogen blast.
- Step 18 Dry in air oven at 150°F.
- Step 19 Wrap in lint-free paper and aluminum foil.