

The Effects of Solder Masks and Conformal Coatings on Microwave Printed Circuit Board Performance

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Insertion Loss (Attenuation)

Insertion loss is made up of:

- Radiation losses
- Conductor losses or Copper losses (DC losses and skin effect losses)
- Material losses or dielectric losses (represented by the Dissipation Factor of the material)

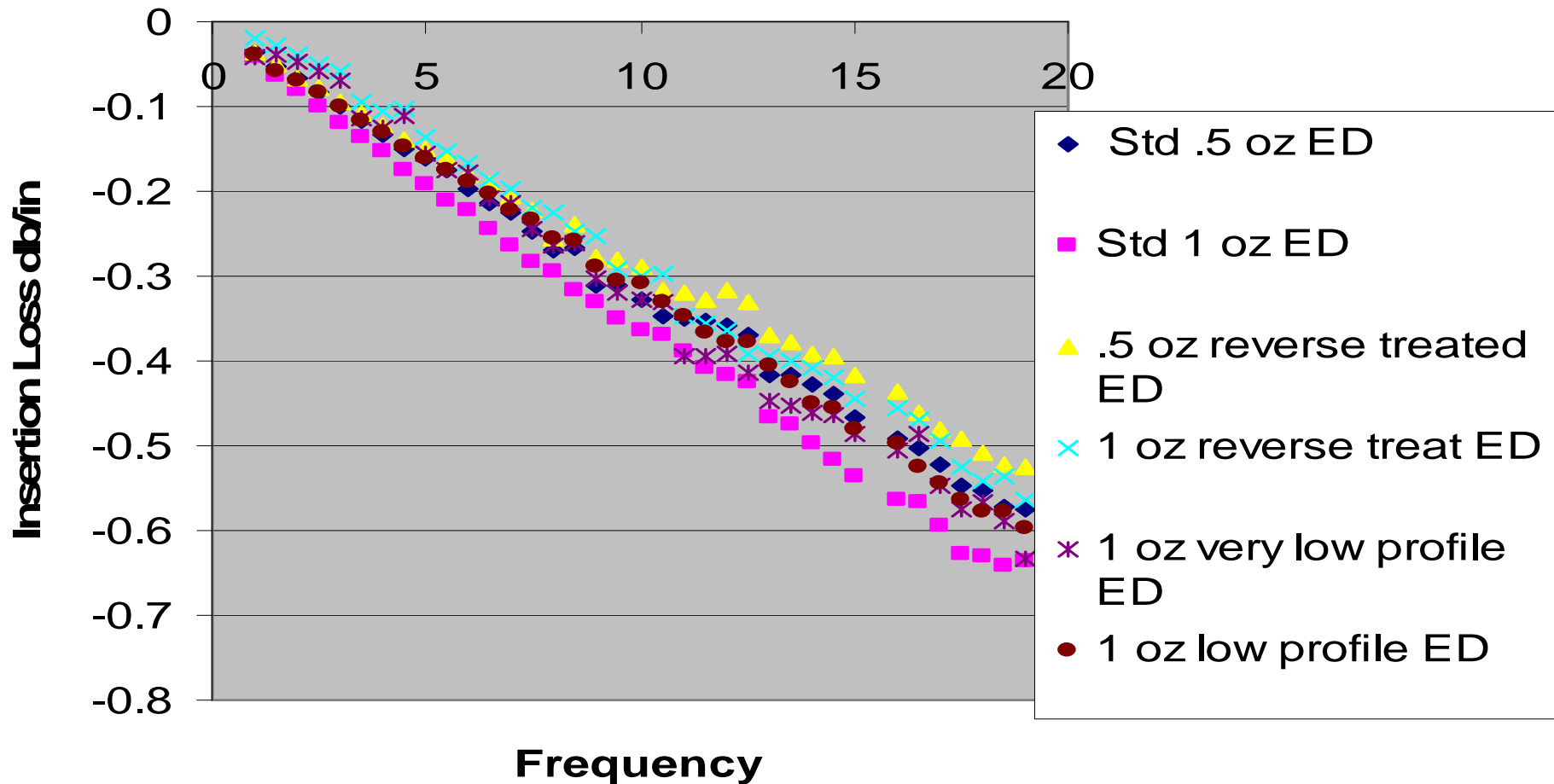
Conductor Losses

What affects conductor losses---

- Type of copper.
 - Rolled annealed
 - Electrodeposited
- Surface roughness of the copper
- Finish plating on the conductor
- Potentially the solder mask or coatings on the board

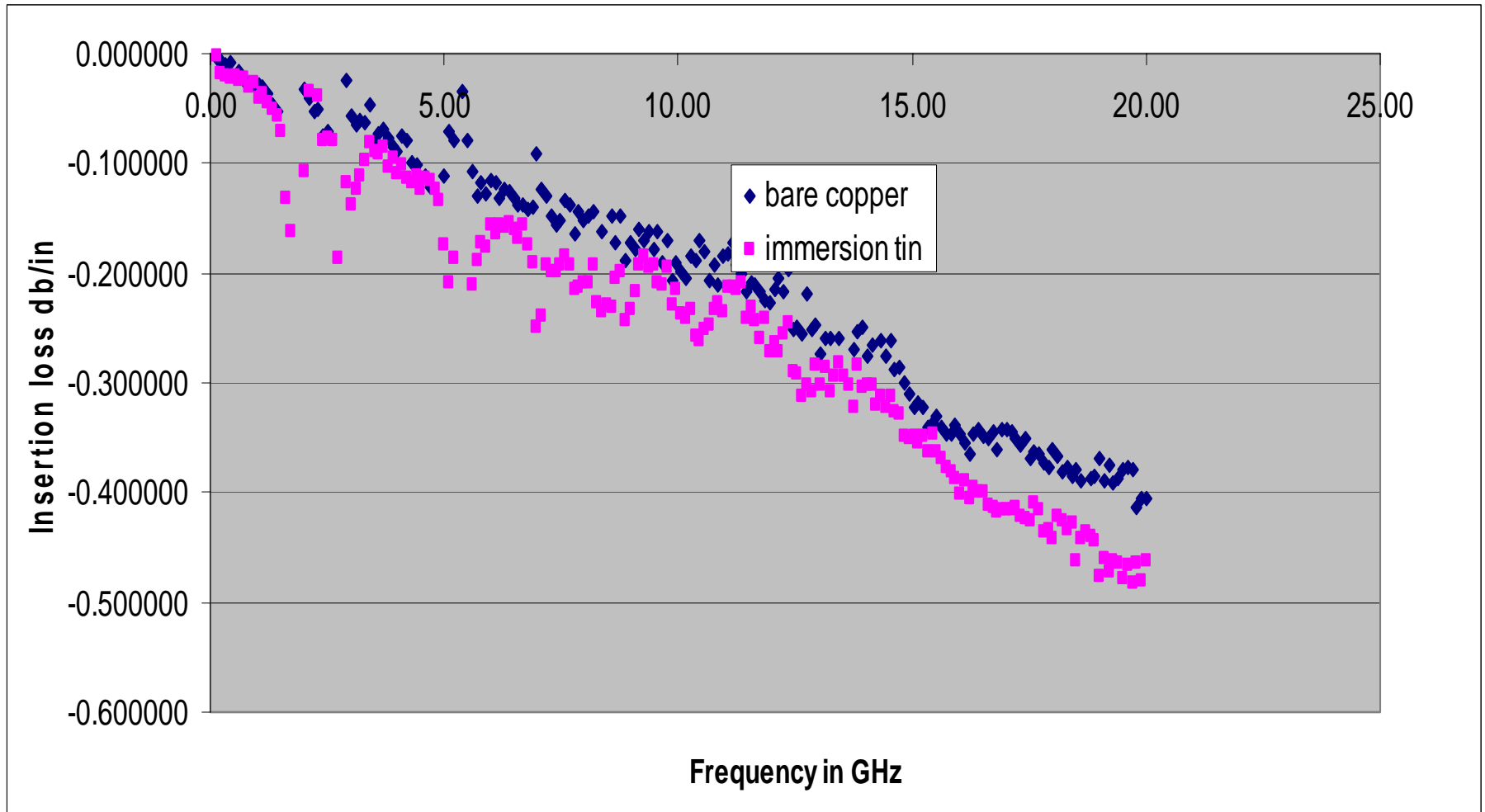
Insertion loss variation with Copper

(laminate 20 mil DT, 46 mil trace width)

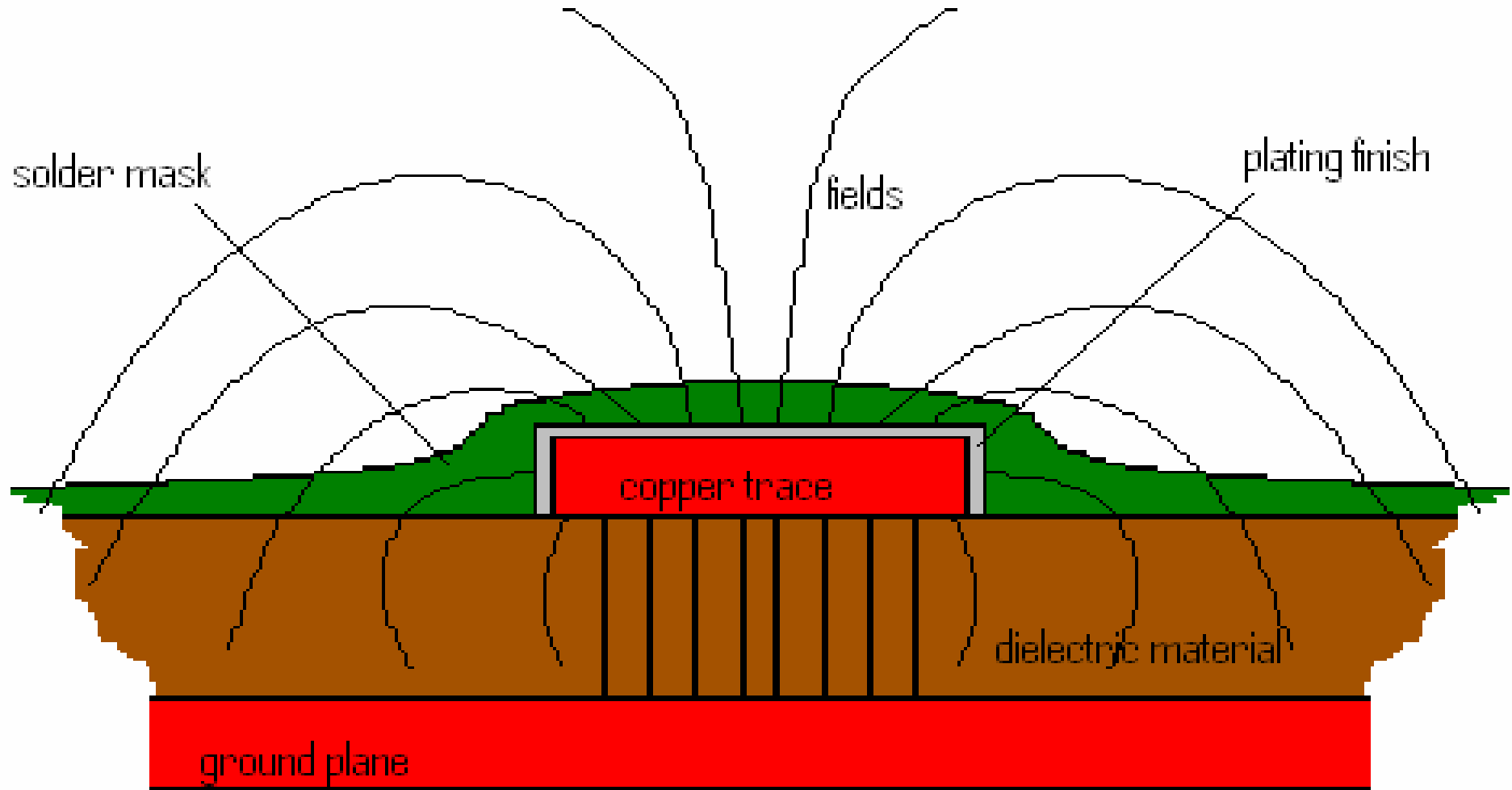


Std .5oz ED: Rms 31; Std 1 oz ED: Rms 64; .5 oz reverse treat: Rms 24; 1 oz reverse treat: Rms 18; 1 oz very low profile: Rms 25;
1 oz low profile: Rms 35 (TL32-0200 based on 4 mil blocks)

Copper vs Immersion Tin



Fields around a trace



Masks and coatings

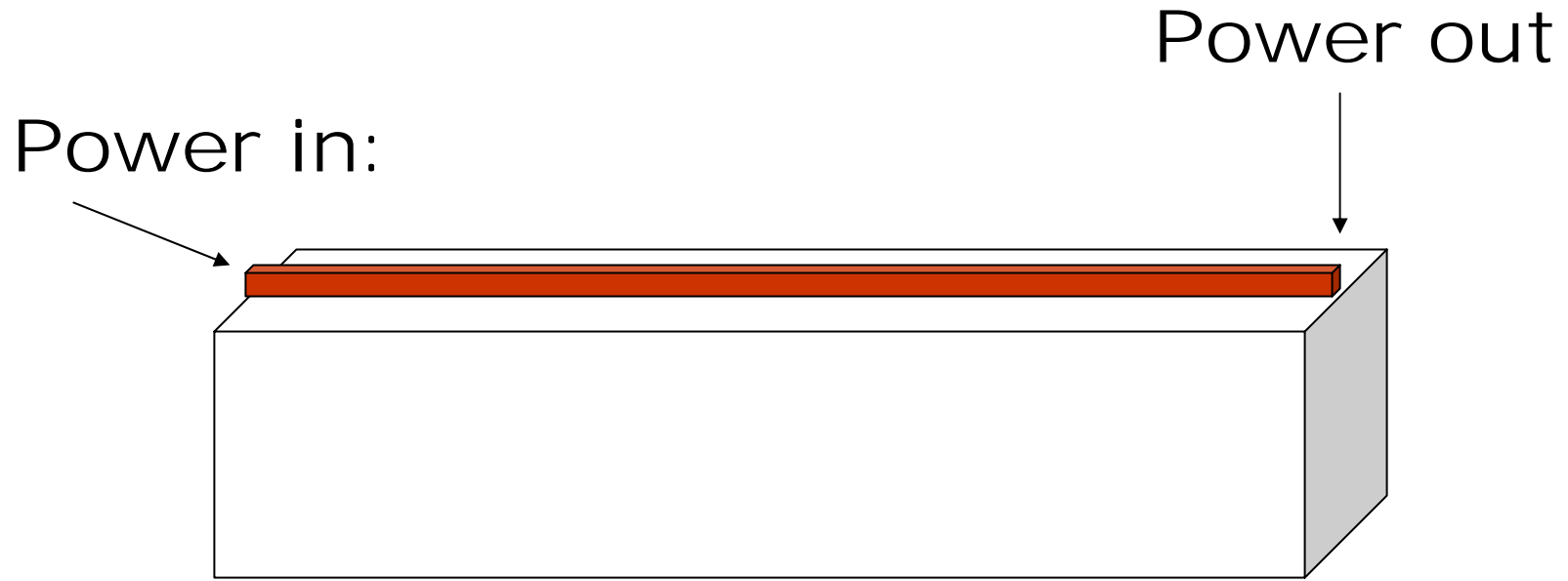
Solder mask materials

- Enthone USR-7 from Cookson UV Curable Screenable formulations for use over copper, tin,
- Taiyo PSR 4000BN Thermally cured solder mask alkaline solution developer
- Taiyo PSR 4000 HG Thermally cured solder mask aqueous sodium solution developer
- TechniMask ISR 1000E Thermally cured solder mask aqueous sodium solution developer
- Sanwa SPSR 950 LC-1 Distributed by Florida Cirtech Thermally cured solder mask

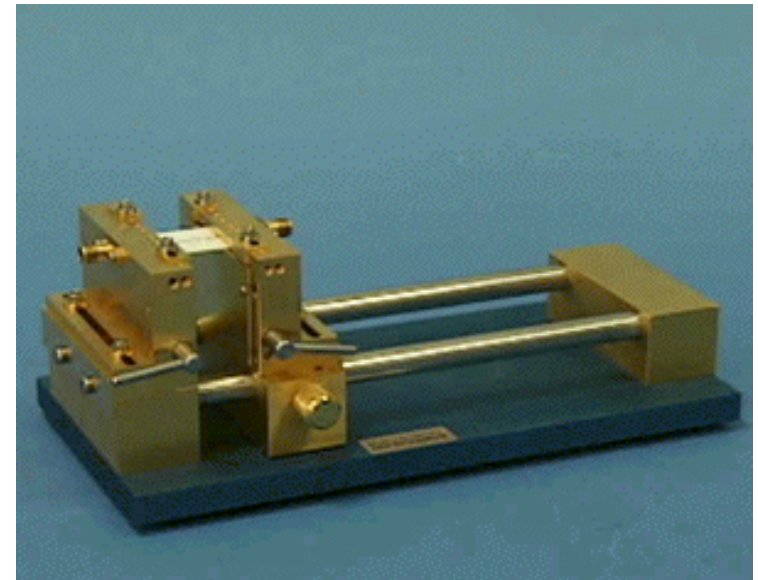
Conformal Coatings

- Humiseal acrylic coatings
- Hysol epoxy conformal coatings

Insertion Loss – loss in power expressed as a function of dB per inch or meter (S21)



Universal Test Fixtures

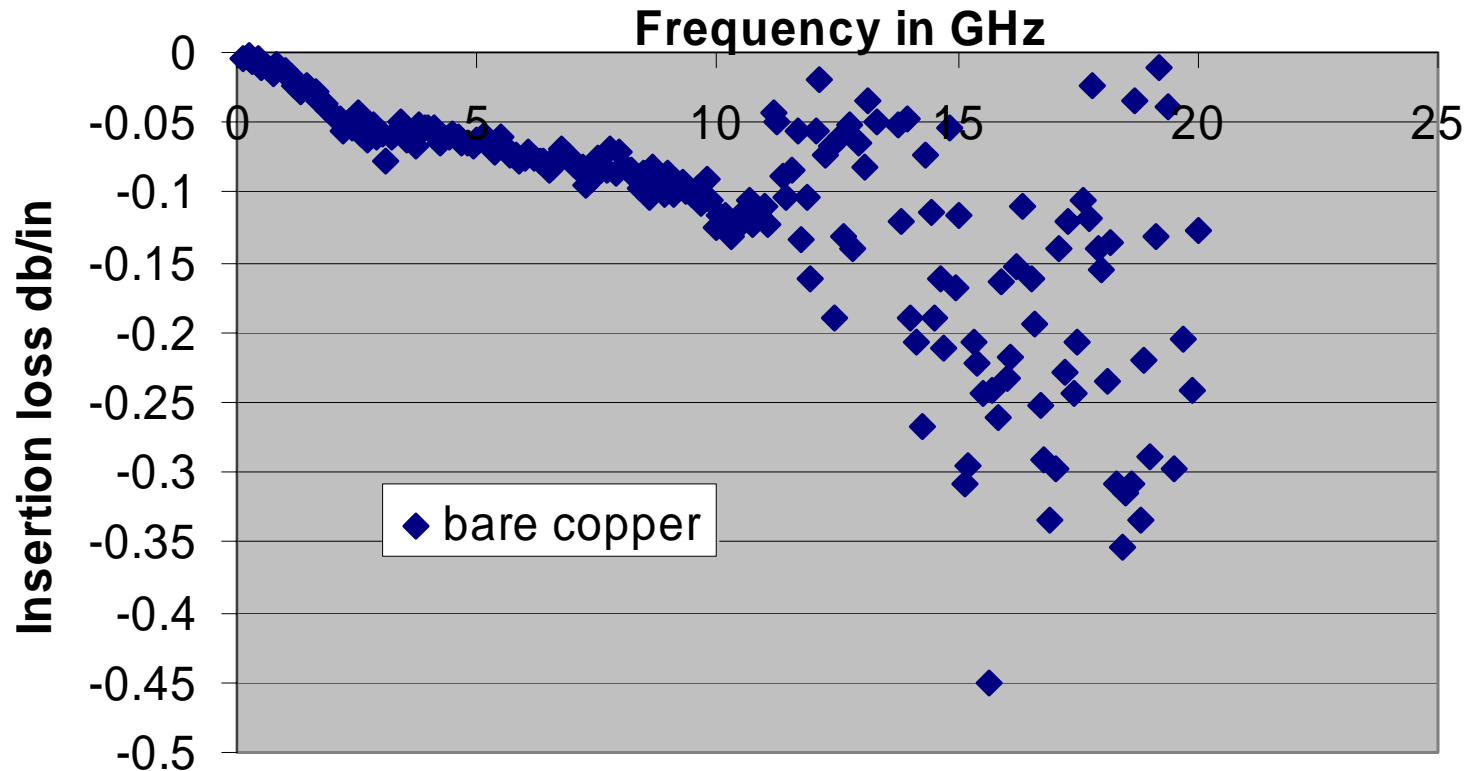


Insertion loss over frequency
Return loss
Impedance measurements

Insertion Loss Experiments

- Step 1 Make sure you have 50 ohms
- Step 2 Look at your return loss and make sure you don't have a lot of reflected power when sending power down an all 50 ohm path
- Step 3 Measure the insertion loss (S_{21})

Bare Copper insertion loss to 20 GHz



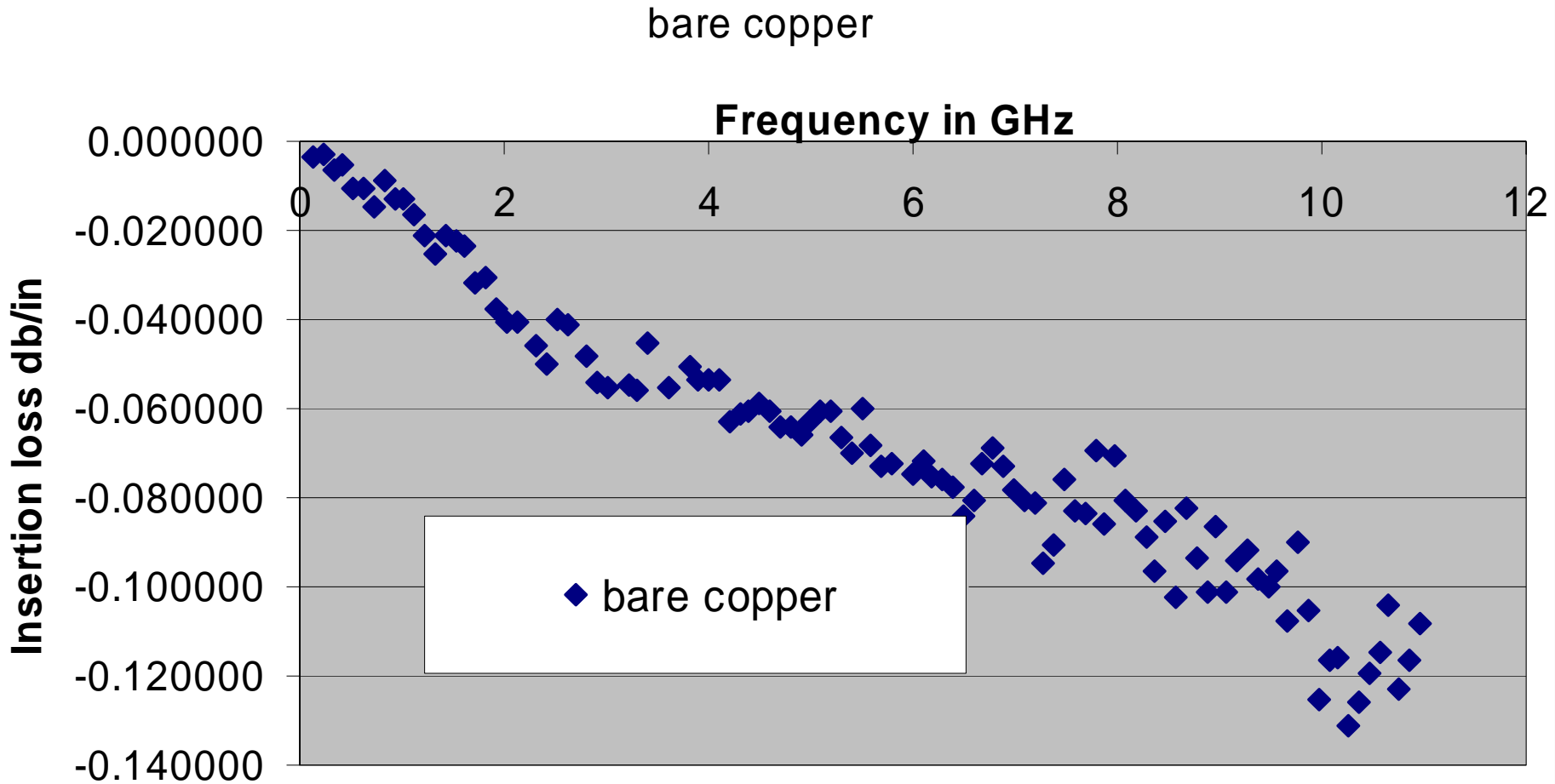
Initial Analysis of Data

- Looked at questionable readings up thru 20 GHz
- Return loss must be 20 db or better to get good readings

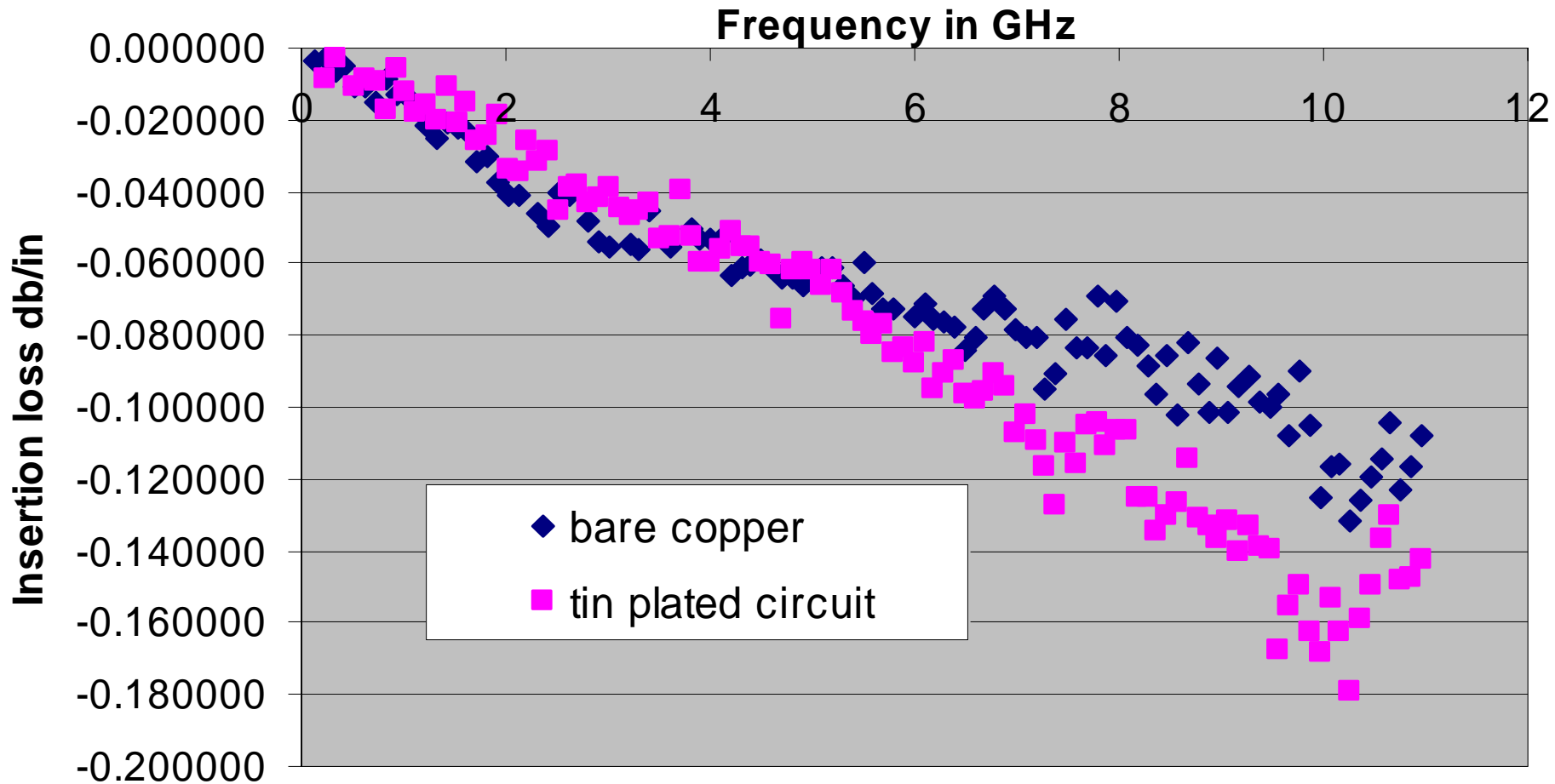
Data Analysis

- Realized that all reading above about 11 GHz were not reliable
- Truncated all data to about 10 GHz

Bare copper



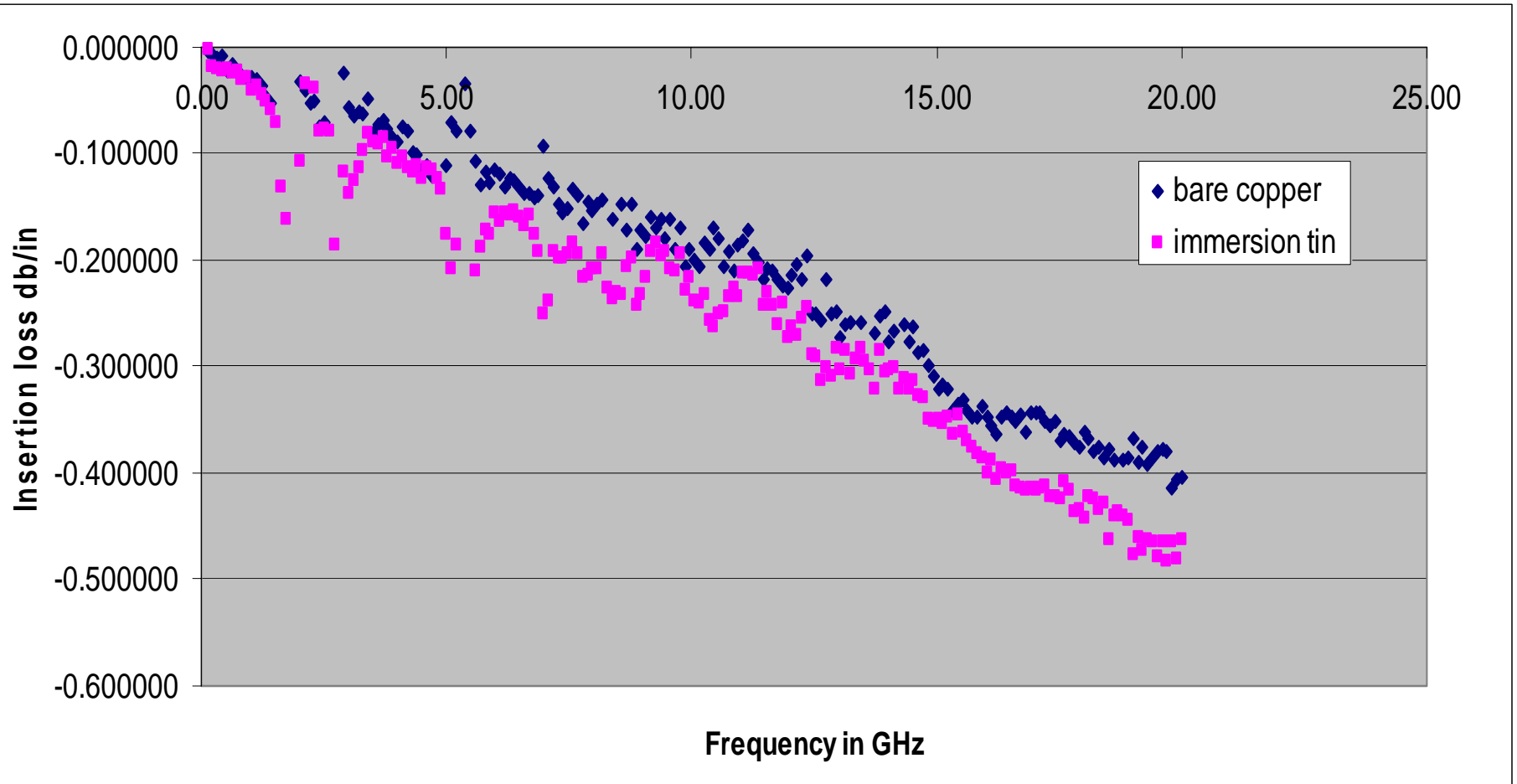
Bare copper vs tin plated finish



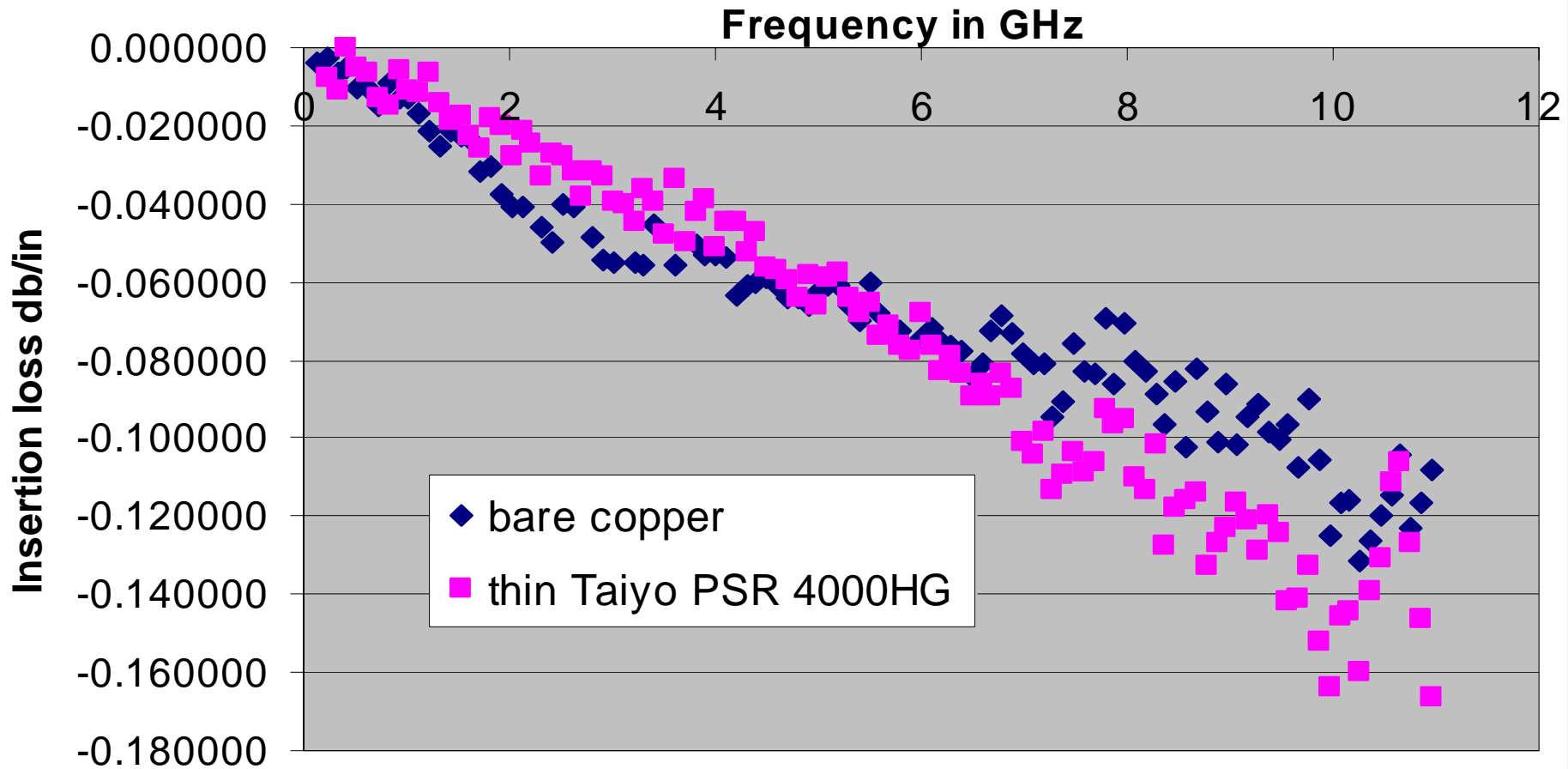
Comparison to former data

- We compared the new data on comparing copper traces with tin plating to data from prior experiments. Although data collected on prior experiments was on a 20 mil thick material and the new data collection was based on a 60 mil material, the data showed similar results.

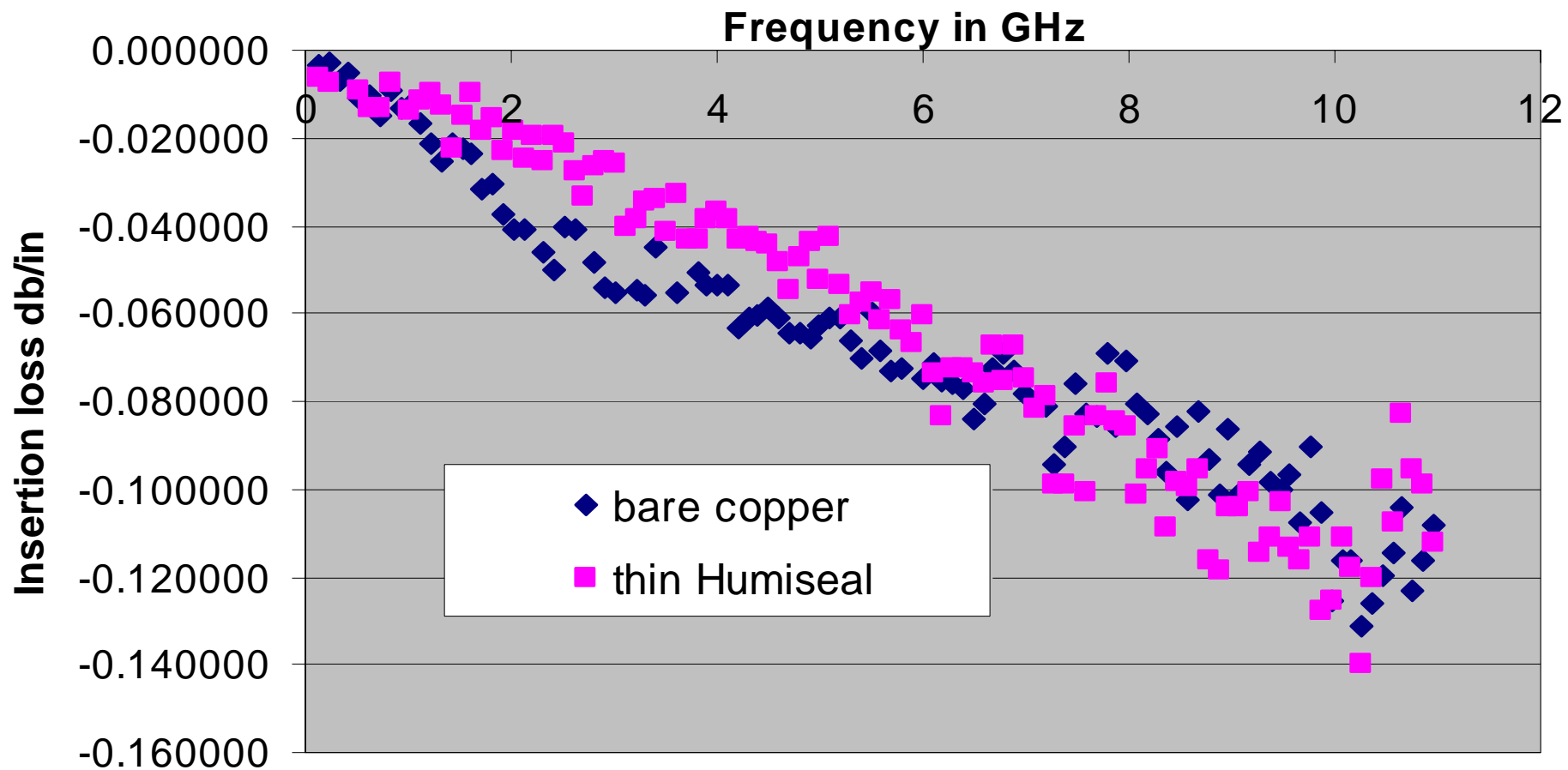
Copper vs Immersion Tin



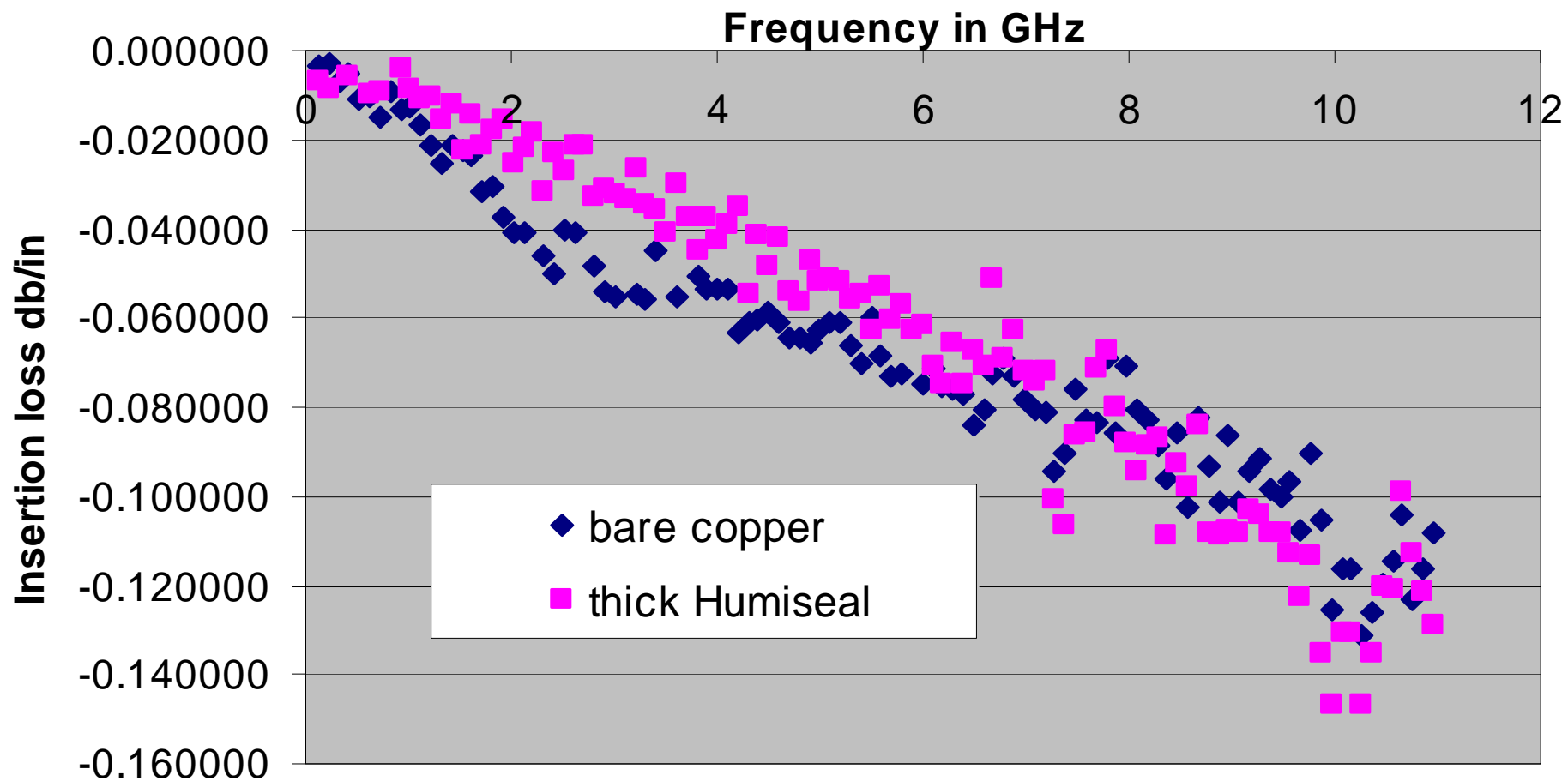
Bare copper vs thin Taiyo PSR 4000 HG



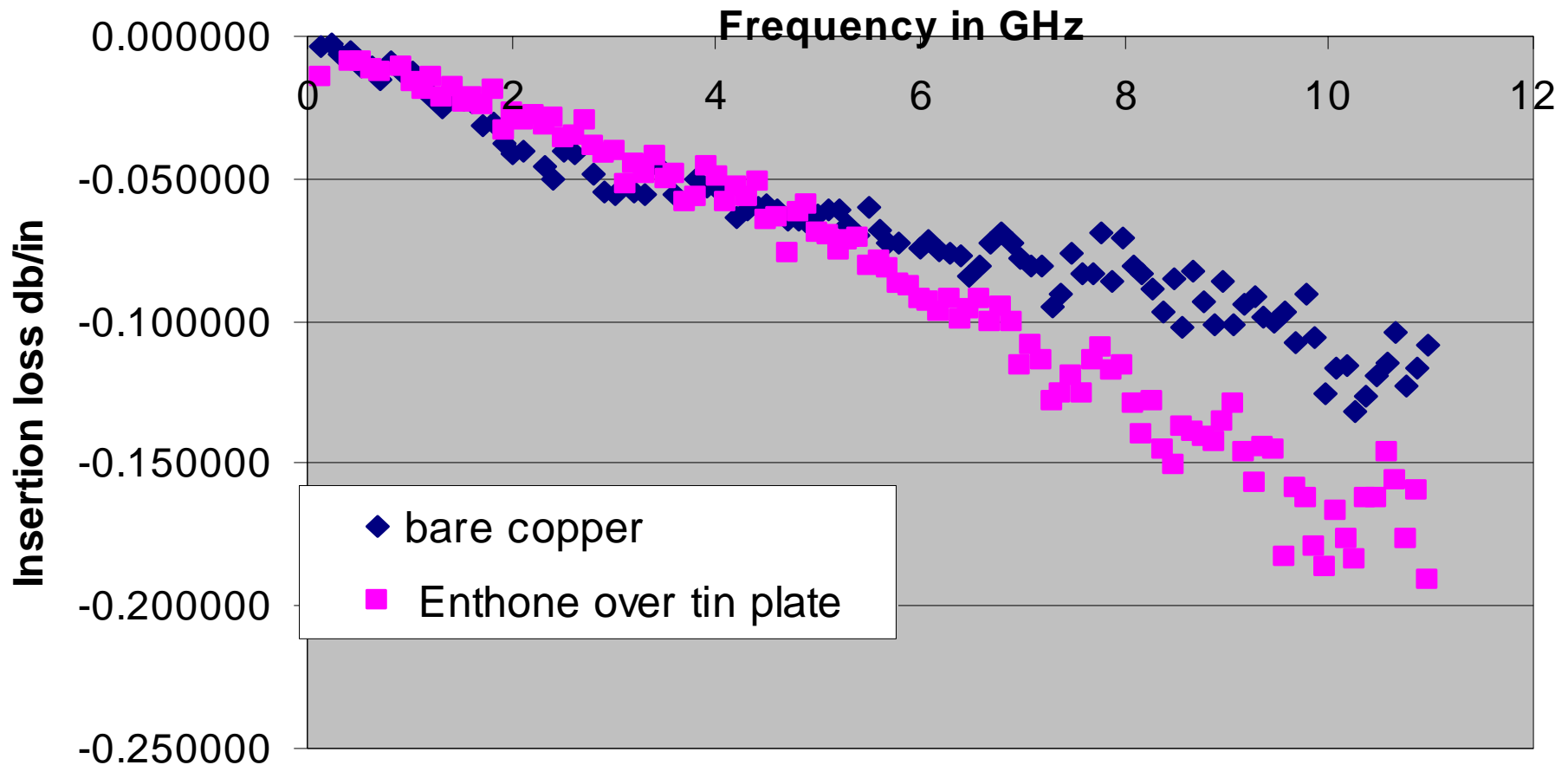
Bare copper vs thin Humiseal



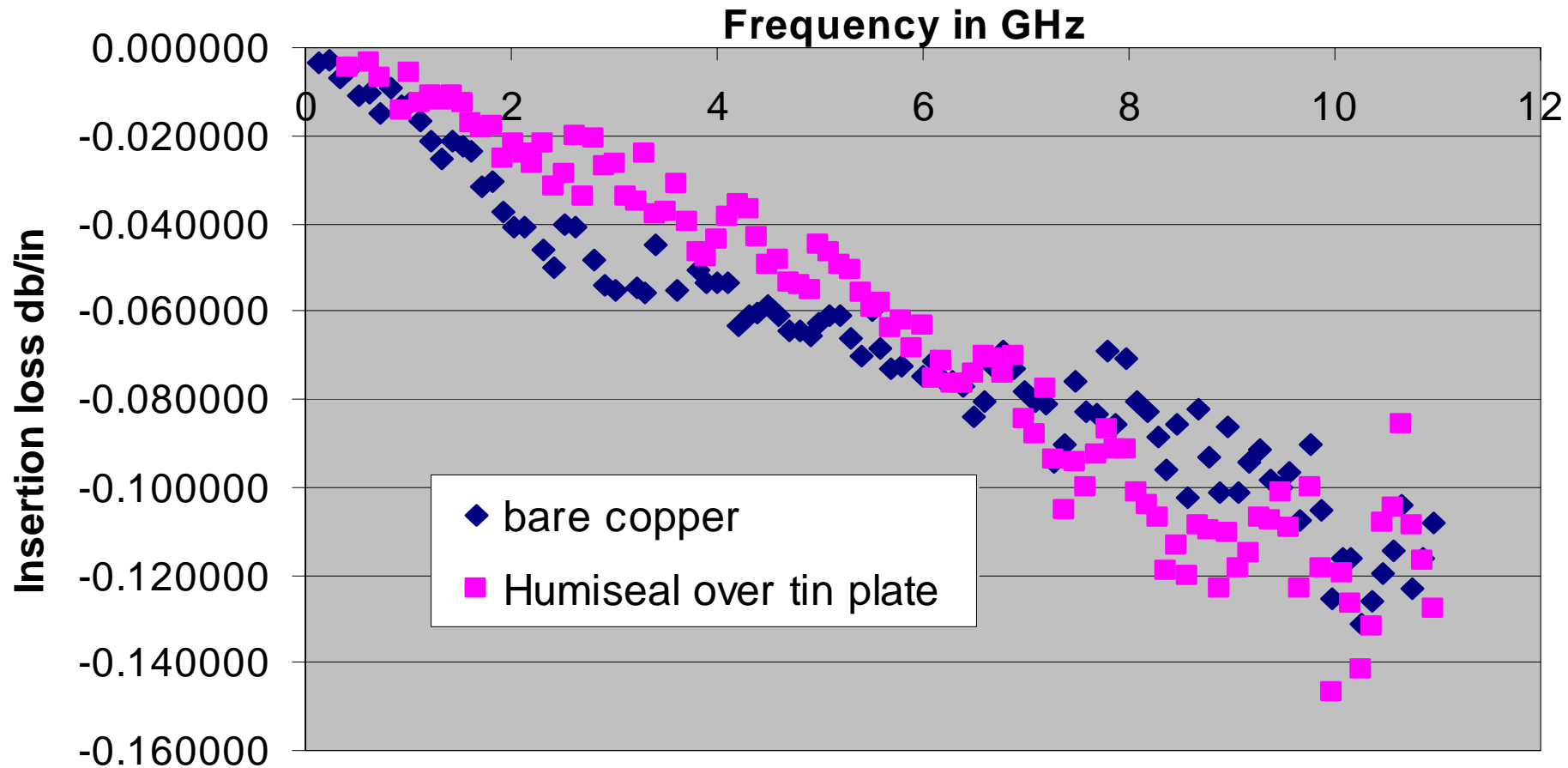
Bare copper vs thick Humiseal



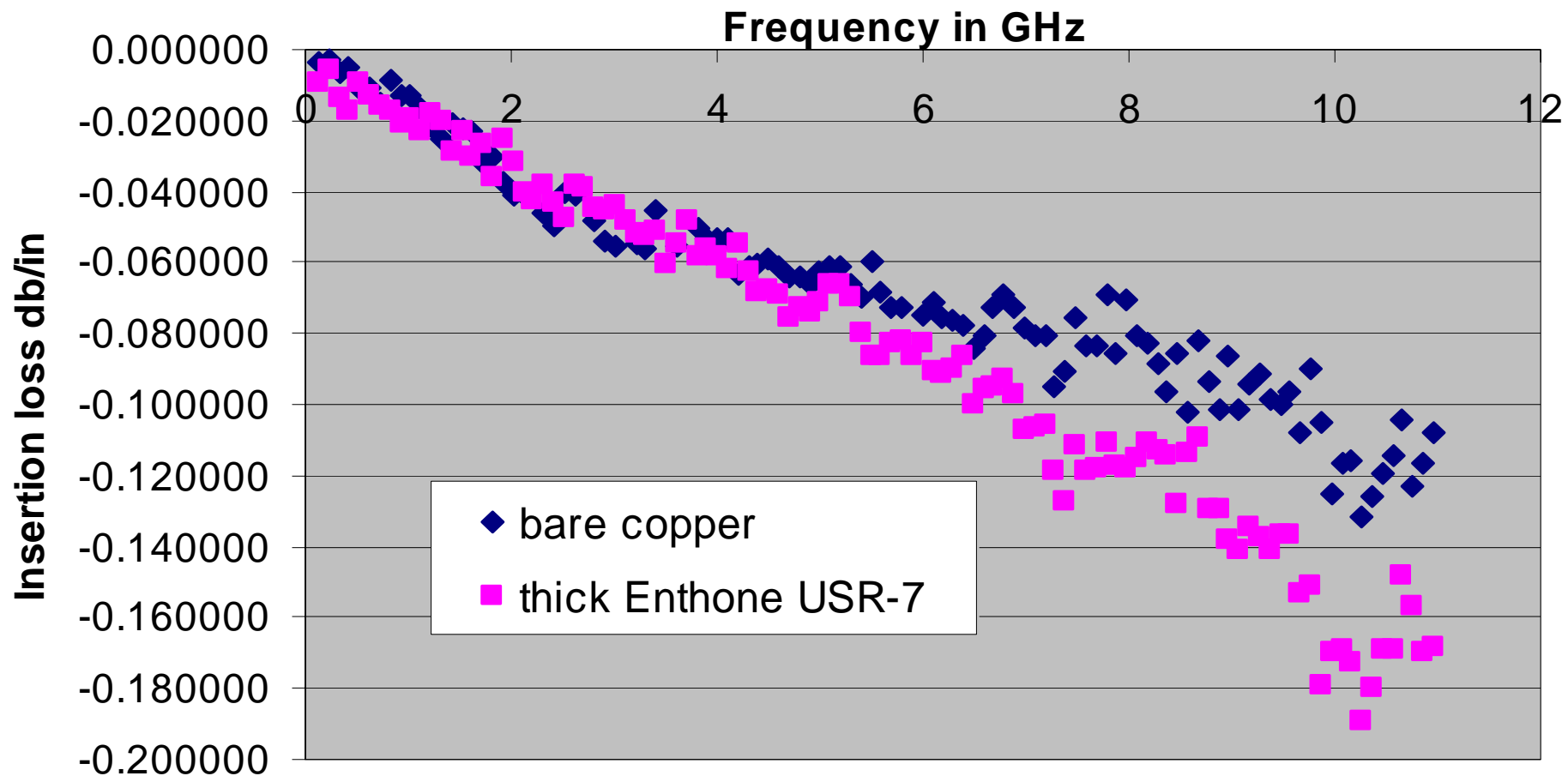
Bare copper versus Enthone over tin plate



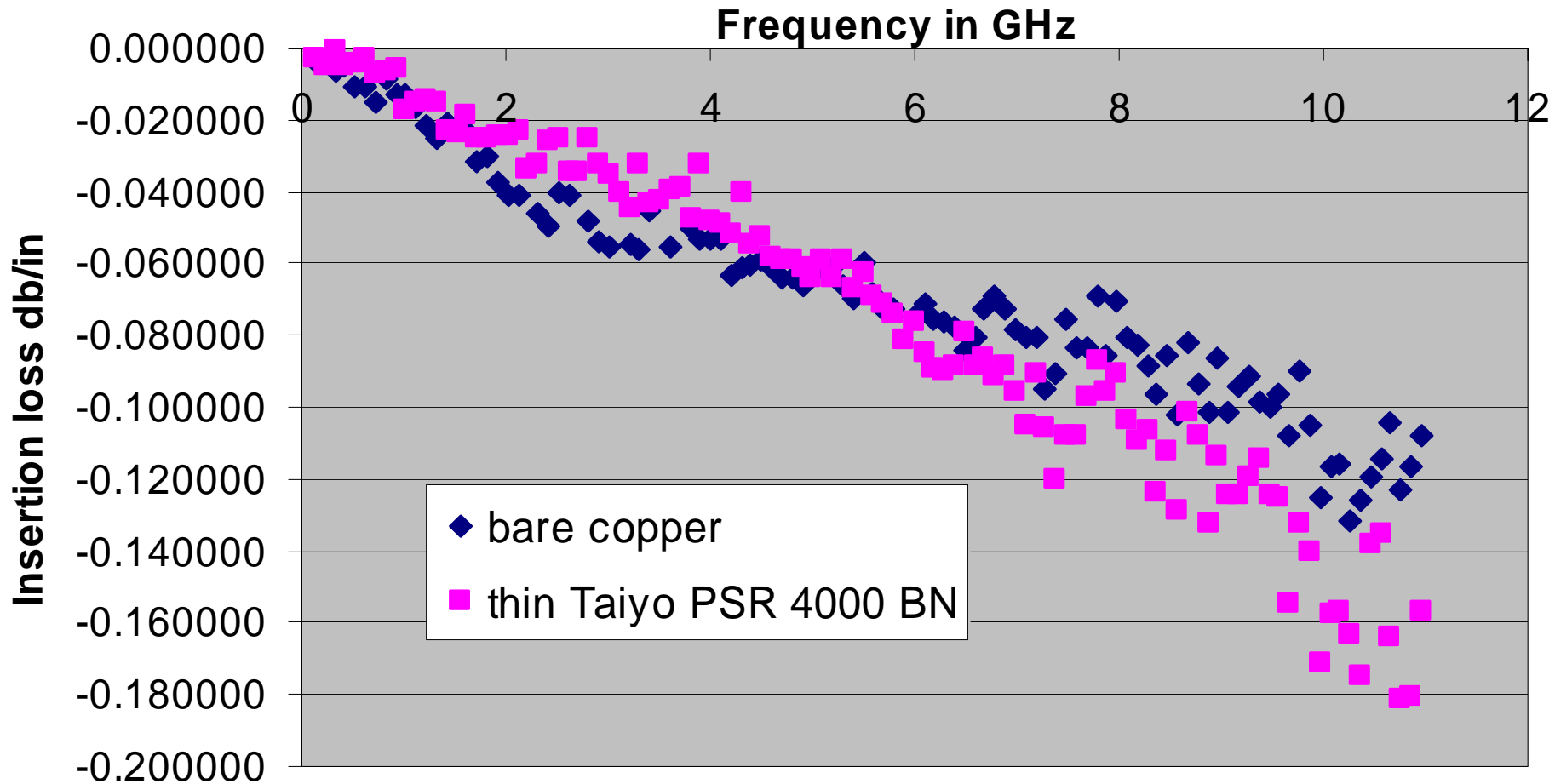
Bare copper vs Humiseal over tin plate



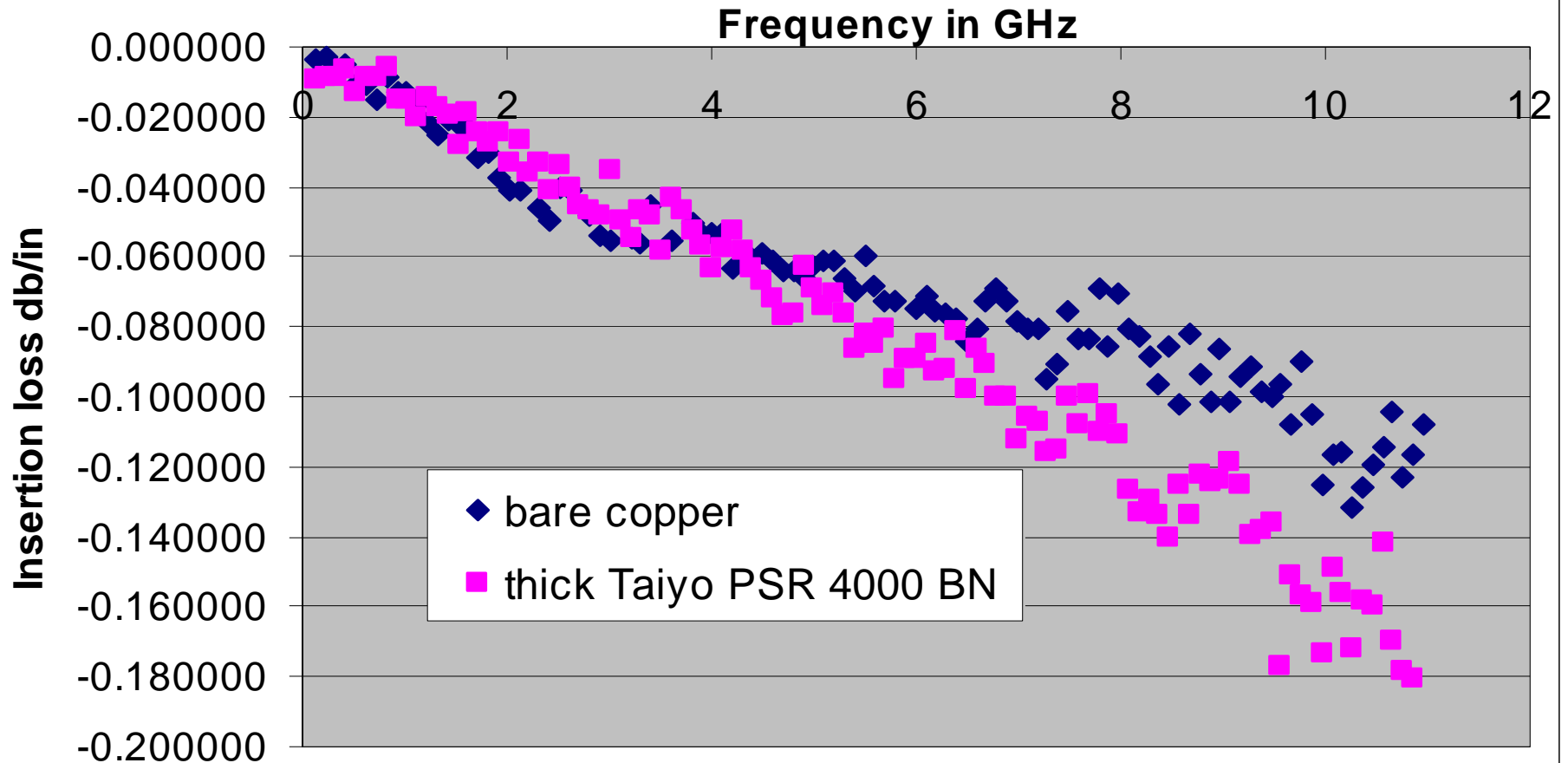
Bare copper vs Thick Enthone USR-7



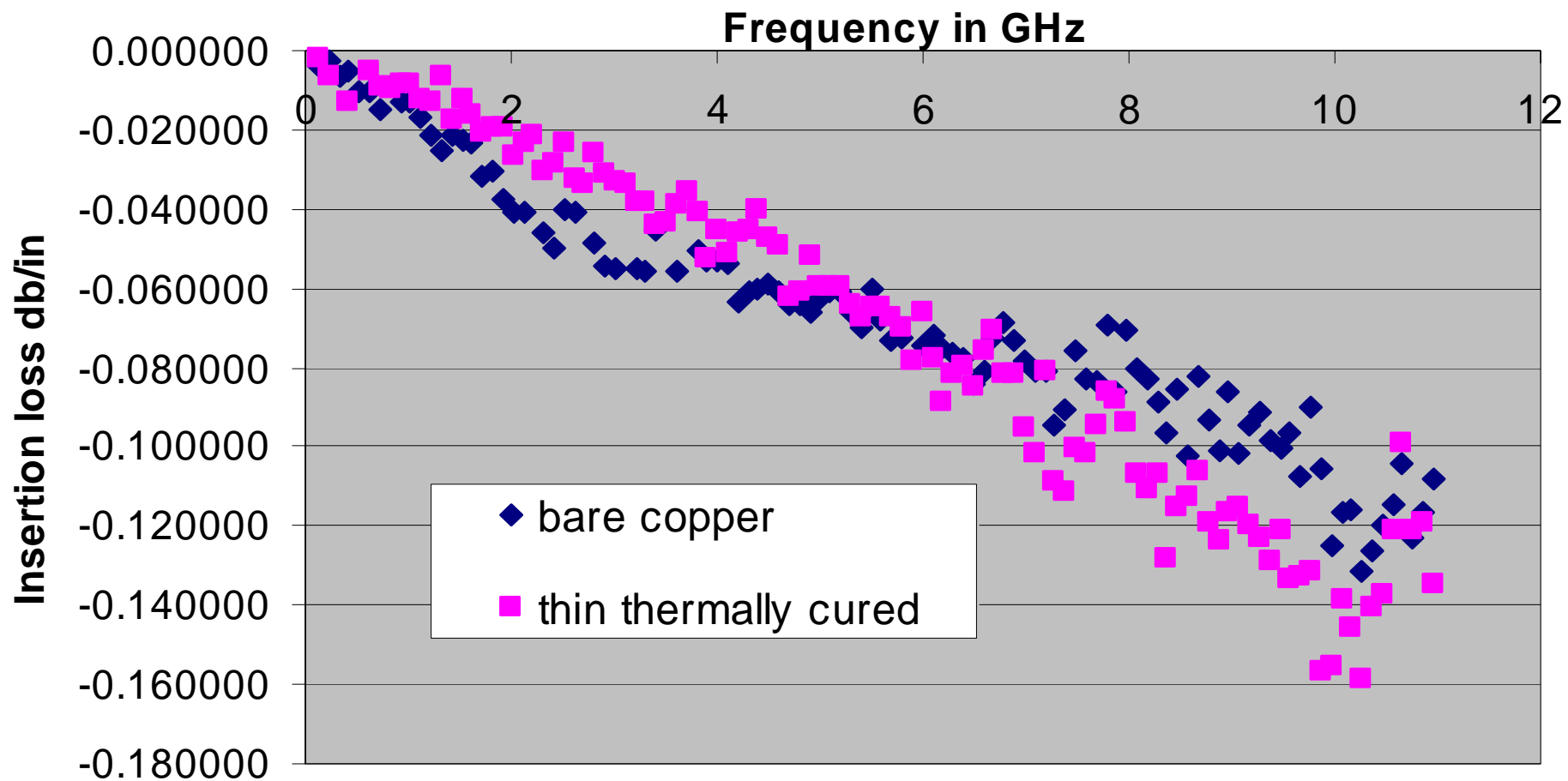
Bare copper vs thin Taiyo PSR 4000 BN



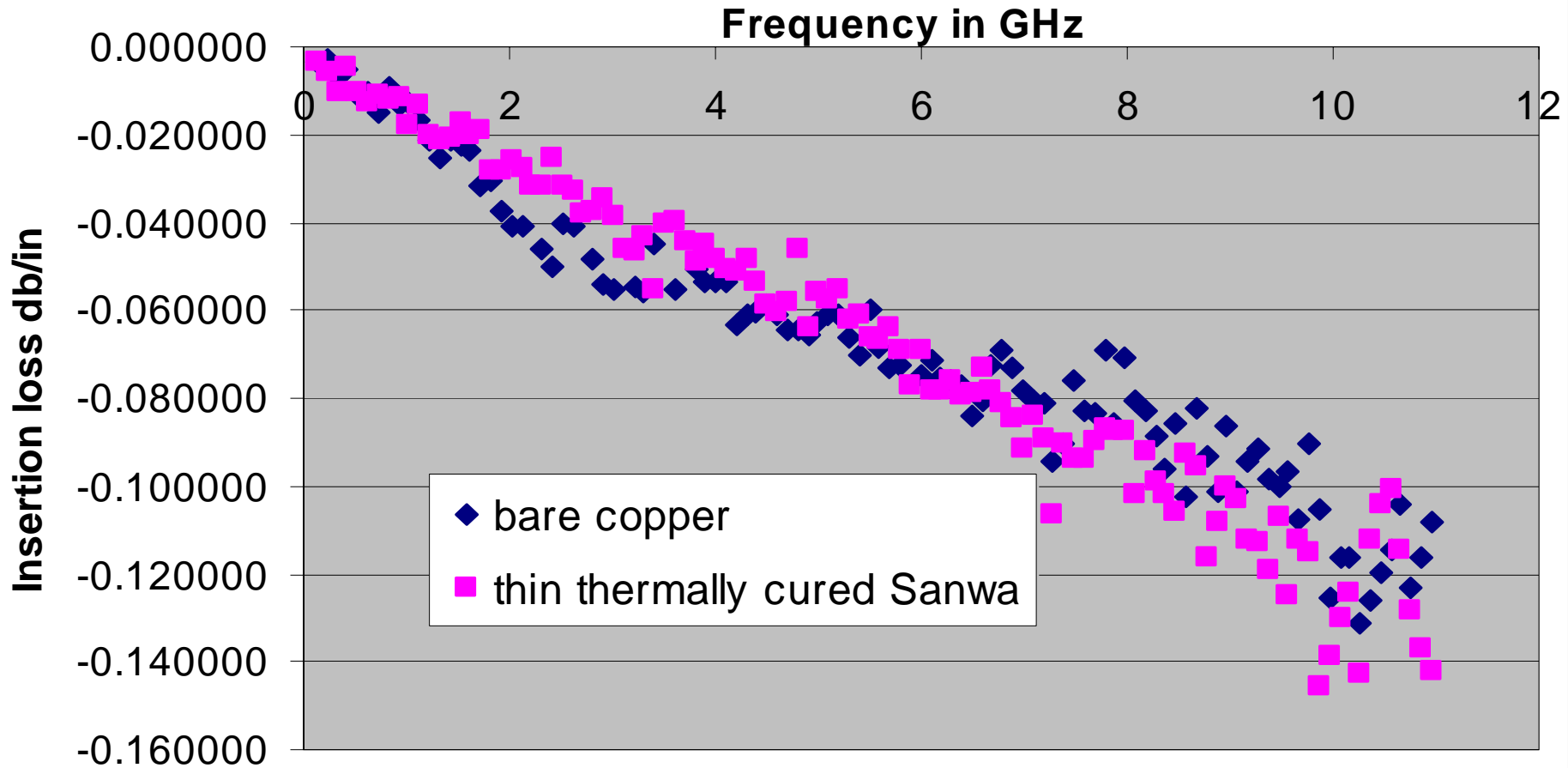
Bare copper vs thick Taiyo PSR 4000 BN



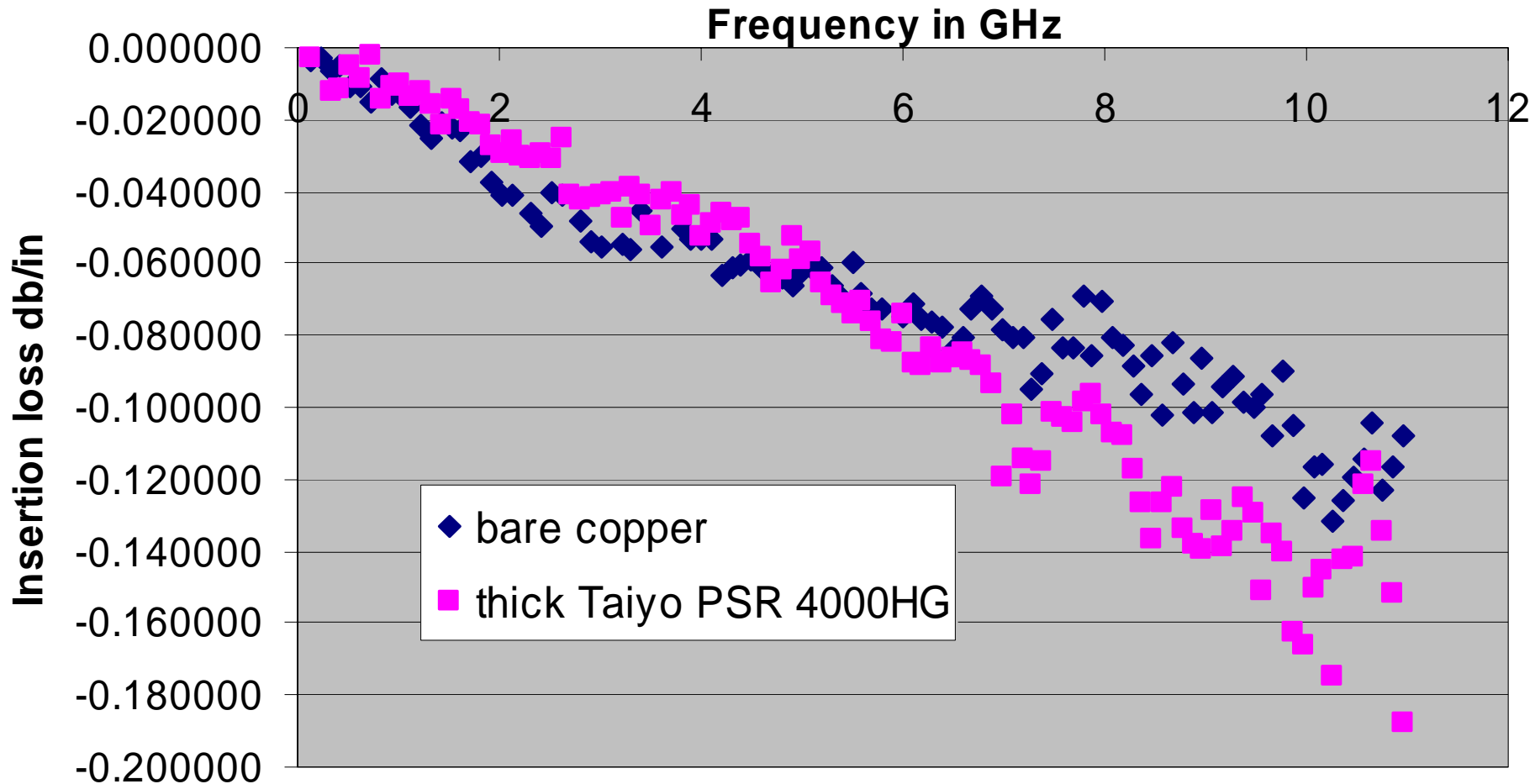
Bare copper vs thin Thermally cured



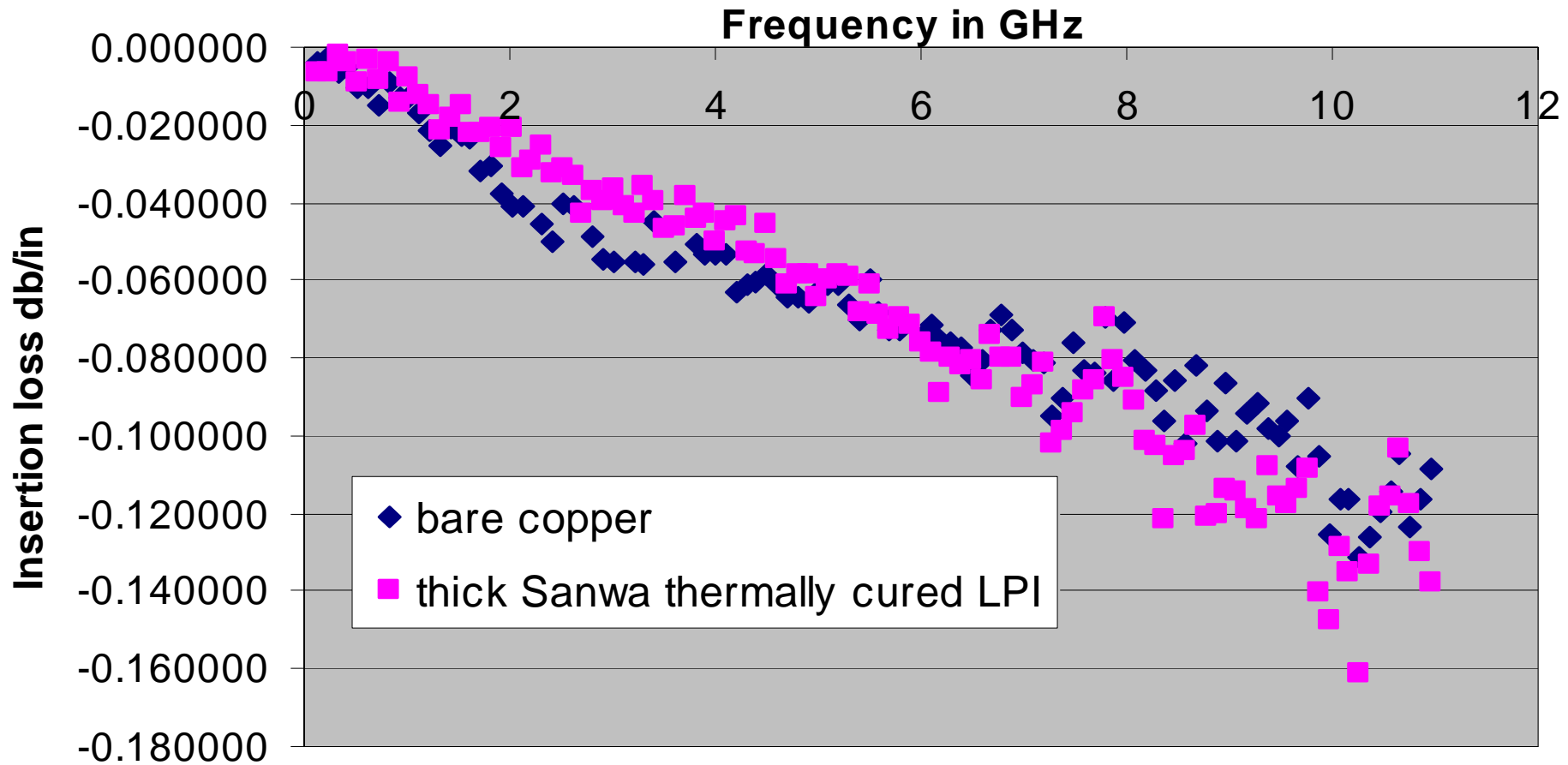
Bare copper vs thin Sanwa thermally cured LPI



Bare copper vs thick Taiyo PSR 4000 HG



Bare copper vs thick Sanwa thermally cured LPI



Observations

As one might expect.. coating or solder masks on microwave printed circuit boards do not have much of an effect at lower frequencies.

As the frequencies get closer to x band we start to see more of an effect on board performance.

The selection of the finish plating on the traces affects the performance more than the solder mask or conformal coatings.

The conformal coatings like Humiseal or Hysol have less of an impact on board performance than solder masks... probably due to the thickness rather than the loss characteristics of the coating material.

The makers of the solder masks and conformal coating have no idea what dissipation factor or losses are in their materials.

Additional data must be taken to see the effect of these coatings at higher frequencies.

Conclusion

The selection of a solder mask or conformal coat is something we usually don't even think about. But as frequencies on designs go higher the mask or coating may have an effect on the board performance. There is no clear cut advantage to any particular system. The designer must understand what his PC board shop can supply and then design his board understanding the effects that it will or might have on performance.

Thank you

I want to thank all the people who helped by supplying samples for this evaluation.

- CCT Excel
- Vermont Circuits
- Mega Circuit
- American Standard Circuits
- MCT

Thank you

Thank you for your attention.

For information about Taconic and our microwave laminate materials, please visit us on the web at www.taconic-add.com.