

## Summary of Meetings with ANL-APS Staff re High Frequency Acceleration

- DW and RS met with Bob Kustom at Indianapolis
- RS met with Yoon Kang, Alireza Nassiri, Joshua Song at ANL

### Papers and Notes

- Y. W. Kang *et al*, "Design and Construction of Planar mm-Wave Accelerating Cavity Structures" RSI **66**, 1(1995)
- P. J. Matthews *et al*, "Electromagnetic Field Measurements on a mm-Wave Linear Accelerator" submitted to IEEE Transactions on Microwave Theory and Techniques
- P. J. Matthews *et al*, "A Preliminary Thermal-Structural Analysis of mm-Wave Electron Accelerating Structures"
- P. Matthews, "Investigations on the mm-Wave Accelerator Project"
- A. Feinerman *et al*, "Micro-Linear Accelerator Project: Preliminary Microfabrication Approaches"
- J. J. Song *et al*, "Fabrication of mm-Wave Cavities Using Deep X-Ray Lithography"
- T. L. Willke *et al*, "Deep Etch Silicon mm-Waveguide Structure for Electron Acceleration"

## LIGA

The LIGA steps are

1. fabricate a low energy X-ray mask using e-beam lithography
2. use it to make a high energy X-ray mask by exposing a sheet of PMMA and then etching and electrodepositing typically 25 - 35  $\mu\text{m}$  thick gold that is required for 1 mm deep features in the final structure.
3. use the high energy X-ray mask to expose a thick sheet of PMMA and then etching the PMMA and electrodepositing copper.

ANL-APS is making a large investment into LIGA, Deep X-Ray Lithography.

- The e-beam lithography is being done at Wisconsin by Wisconsin staff.
- Until recently the high energy X-ray mask was also being made by Wisconsin, but ANL is now doing this work at Alladin.
- The high energy X-ray exposure is being by ANL at NSLS. They expose the PMMA there, and then do the etching and electroplating at University of Illinois - Chicago. (They cannot get the chemical processes used past the ANL ESH people.)

## Comments

- The etching and electroplating must be done within a few days of exposure. Otherwise the PMMA develops cracks.
- Although LIGA is widely advertised, there are many steps in the process that are known only to practitioners.
- They do not share them freely because of patents and the potential commercial market.
- Henry Guckel at Wisconsin is the master of this art, but he is on the road so much that he is difficult to engage. It is possible to get the attention of other members of Guckel's group.
- ANL has had to learn many of the techniques by trial and error. Joshua Song estimates that he is spending 80% of his time learning LIGA.
- Example of a problem - PMMA has to be glued to a copper plate before exposing. They encountered problems with the glue joint, cracking of the PMMA during hard X-ray exposure. They decided this was a combination of chemical and heating effects. Now attach the copper plate to a water cooled heat sink and perform the exposure in a Helium atmosphere.
- Each new geometry takes ~ 1 month from drawings for the e-beam lithography to the final structure.
- They have yet to make a satisfactory structure although I saw one-half of a ~ 25 cell, 108 GHz that had only minor flaws.
- Their immediate plans are to fabricate some complete 40 and 80 cell, 108 GHz structures and measure them with a high frequency Network Analyzer at Univ. of Illinois - Urbana.
- A LIGA beam line is being constructed at the APS as a collaboration of the accelerator people and the APS Experimental Facilities Division.

- **They are happy to work with us and let us learn the techniques they have developed so far. This could include working with them on the different steps of making a structure.**
- They have made some inquiries about structure fabrication with EDM, but rejected that due to experience at Grumman that implied a frequency limit of  $\sim 35$  GHz.