9.2: Fabrication Techniques for a THz EIK

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Abstract: *To produce an EIK working at THz frequencies, departure from traditional fabrication techniques is required. This paper describes the investigation and results of various fabrication techniques and their suitability for application in a VED.*

Keywords: THz; EIK; UV Lithography; X-Ray Lithography; EDM; Micromachining.

Introduction

Work is currently underway to design and produce an Extended Interaction Klystron (EIK) operating at THz frequencies. A summary of the target parameters is presented in Table 1.

Table 1. Program Goals

Parameter/Unit	Phase I	Phase II	Phase III
Frequency/THz	0.670	0.850	1.030
Pout (CW)/dBm	27	25	21
Gain/dB	23	23	21
PAE/%	0.75	0.50	0.20
Instantaneous bandwidth/GHz	15	15	15

To realize an EIK at these frequencies, fabrication techniques beyond those normally used for an EIK are required. This paper describes those techniques under investigation, and the results obtained to date.

Ladder Fabrication

The EIK cavity is based on a ladder circuit. Traditionally, this is manufactured using a sink EDM technique. For this program the required size of the ladder slots is projected to be smaller than the capability of the sink EDM process, therefore alternate techniques are required.

RF simulations have predicted that slot width between .001 and .002 inches will be required. Two main avenues are under investigation to produce such circuits; Lithography and Micro-Machining.

Lithography. The lithography process involves 2 steps. Firstly, a mold is produced in a polymer photoresist, then metal (in this case copper) is electroplated into the mold to produce the final part. The biggest challenge in the production of the molds is the stability of the formed posts, given the high aspect ratio of the features required.

Two lithography techniques are being assessed, Ultra-Violet lithography and X-Ray lithography.

UV Lithography. Two investigations using UV lithography are underway. Creatv MicroTech is working with an SU-8 photoresist, and the University of Virginia is working with a KPMR photoresist. Both programs have successfully produced sample ladders with slot widths as small as .001”, as illustrated in Fig. 1.

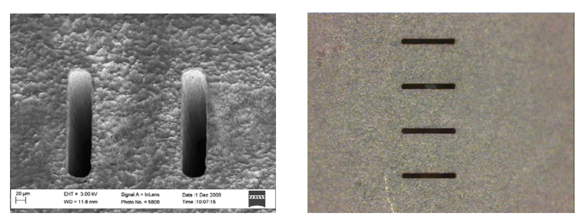

Figure 1. Trial circuits with .001” slot widths produced using UV Lithography by University of Virginia (left) and Creatv MicroTech (right)

X-Ray Lithography. Creatv MicroTech is also working on producing trial circuits using X-Ray lithography. At the time of writing completed parts have not been produced.

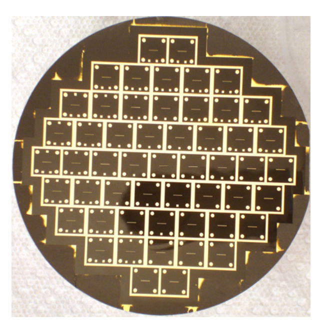

Figure 2. X-Ray mask produced by Creatv MicroTech

Micromachining

As an alternative to a Lithography process, machining processes are being considered. These started with traditional sink EDM and expanded to wire-EDM and laser cutting. These techniques have the advantage that they are usable on a wider variety of materials than the Lithography based processes, which can have advantages for a VED application.

Sink EDM. This is the traditional method used to produce EIK ladder circuits at CPI Canada. Initial test had success producing ladders with slot widths of between .002" and .003", however this proved to be an unreliable process due to difficulty in controlling the electrodes at the small dimensions required.

Wire EDM. An alternative method to sink EDM is to use Wire EDM. Samples were successfully produced with a slot width of .0013", as shown in figure 3

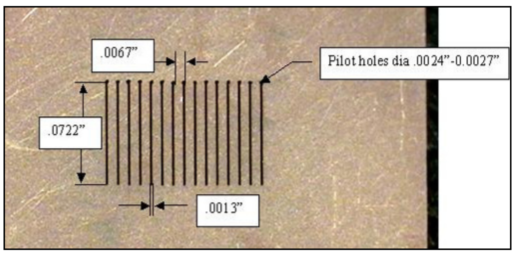

Figure 3. Wire EDM Ladder Circuit, CPI Canada

This process required the drilling of pilot holes at the end of the slots. This has the potential of changing the RF behavior of the ladder, but computational analysis has showed that the effect is minimal.

Laser Machining. The final alternative being investigated is the machining of the ladder slots using a picosecond laser ablation method.

Beam Tunnel Fabrication

Fundamental to the operation of a linear beam VED is the formation of a straight and accurate beam tunnel, through which an electron beam can be focused. For the device under consideration here, a beam tunnel diameter of .005" over a length of up to 1" is required.

Sink EDM. The traditional method of forming the beam tunnel in an EIK ladder is to use a Sink EDM process. The smallest operational beam tunnel to date has been Ø.007" over a length of .600". Sink EDM techniques at CPI Canada were refined, and to date a beam tunnel of Ø.005" over a length of .585" has been demonstrated.

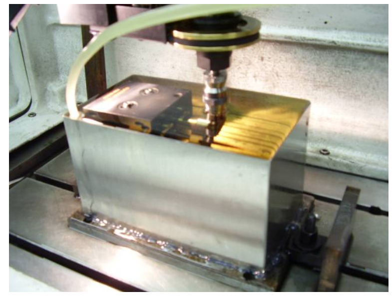

Figure 4. Sink EDM machine at CPI Canada

Progress beyond a length of .585" has proved difficult, primarily due to difficulties stabilizing the very small electrode with length extended to drill a longer hole.

Wire EDM and diffusion bonding. An alternate method of fabricating a precision beam tunnel over an extended length is to pre-form half beam tunnels using a wire EDM process, and then bond two parts together to form the complete tunnel. Experiments have been performed with promising results. Figure 5 shows an end view and a section showing the bonded seam.

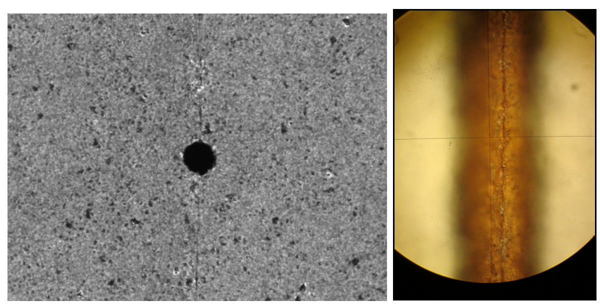

Figure 5. Diffusion bonded Ø.005" beam tunnel by CPI Canada (End view left, section right)

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