Project name

Expression of Interest in Research and Development of Methods for Producing GEM Detectors, and Their Incorporation in Forward Tracking Systems at the NLC.

Classification (accelerator/detector:subsystem)

Detector:Tracking

Institution(s) and personnel

Louisiana Tech University, Center for Applied Physics Studies:
Lee Sawyer (*), Tony Forest, Z.D. Greenwood, Neeti Parashar (professors)
Prabir Roy (applications physicist)

Louisiana Tech University, Institute for Micromanufacturing
Phillip Coane (Senior Engineer)

Contact person

Lee Sawyer
sawyer@phys.latech.edu
(318) 251-2407

Project Overview

Gas Electron Multipliers (GEMs) are becoming a plausible option in experimental particle physics for use as a position measurement device [1]. The main component to a GEM is a thin polymer (kapton) foil, metal-clad on both sides and perforated by holes having a radius on the order of 50 ?m in a grid pattern in which the distance between adjacent holes is on the order of 100 ?m. Typically, the holes in this grid pattern are chemically etched after photo-lithography. The foil then acts as a pre-amplifier when immersed in the gas volume and can be used by particle detectors which operate by ionization. Charge multiplication occurs when the electrons pass through the foil holes whose sides have had an electric potential difference applied to produce electric fields on the order of 40kV/cm. The transmission of all electrons (full transparency) is one of the key issues in GEM design. A typical GEM detector electric field is shown in Fig. 1.

As seen in Fig. 2, the present technique of photo-lithography does not always produce a pattern of uniformly shaped holes; in some cases, the etching process failed to create a hole. Although basically a simple procedure, photo-lithography is delicate procedure in this application due to the stringent requirement of a good insulator between the conducting sides of the foil. Foils produced in this manner need careful cleaning to remove any conducting debris and are baked in a vacuum in order to improve the insulation quality. An alternative to photo-lithography which will improve the uniformity and integrity of the GEM foils is needed.

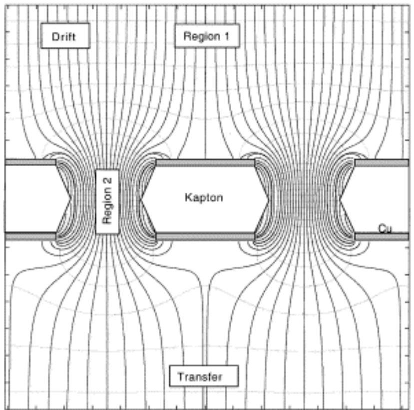

Figure 1 Electric field lines in an operating GEM. Taken from Ref. 3.

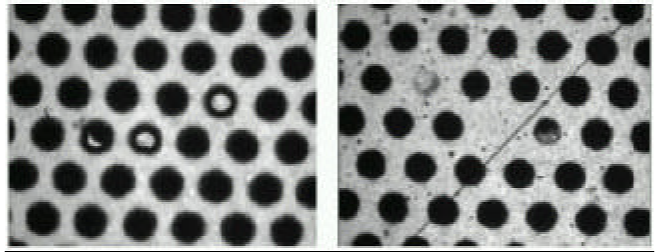

Figure 2 Defects in chemically etched GEM foils, showing misshaped and missing holes. Taken from Ref. 2.

We would like to pursue the development of GEM foils by combining a variety of micromachining techniques. These include refinements on the present photolithographic techniques, laser drilling via a free electron laser, and hot embossing. The Institute for Micro-manufacturing, located at Louisiana Tech, can drill a mask for the photolithography and laser drilling prototypes, and can produce molds for hot embossing of foils up 10 cm X 10 cm. For the laser-drilling technique, we will produce test masks of radiation-hard material, which will be placed in front of a GEM foil for the purpose of drilling the 50 ? m holes using the high intensity power of a free electron laser. We are currently pursuing two options for electron-beam time: The Continuous Electron Beam Facility at Jefferson Lab, and the CAMD Electron Beam facility at Louisiana State University. The later facility is partnered with Louisiana Tech's Institute for Micro-manufacturing as part of a state-wide micromanufacturing initiative, and Louisiana Tech has x-ray lithography beamlines at its disposal.

As an application of GEM technology in subdetector systems at the NLC, we will explore the use of GEM in forward tracking. It will be important to accurately measure differential luminosity cross-sections at the NLC, with angular resolutions on the order of 0.1 mrad [4]. The GEM strategy offers the possibility of achieving the necessary spatial resolutions with a detector that is radiation-hard, high rate, and compact. Timing resolution on the order of 14 ns have been measured with GEM detectors having a 3 mm gap, which is an order of magnitude larger than the 1.4 ns bunch crossing foreseen for the NLC. Research needs to be done to understand if faster timing can be achieved, possibly with MSGC's using a GEM foil preamplifier.

References

1) For a general discussion of GEM detector technology, see the papers listed on http://www.jlab.org/~gen/detectors/literature_gem.html

2) ``Quality Control Of Gem Detectors Using Scintillation Techniques." F.A.F. Fraga, S.T.G. Fetal, R. Ferreira Marquez, A.J.P.L. Policarpo , Nucl.Instrum.Meth.A442:417-422,2000

3) “Detection of single electrons emitted by internal photocathodes with the Gas Electron Multiplier (GEM)” Archana Sharma Nucl. Instrum. Meth. A462:603-606, 2001

4) “Linear Collider Physics Resource Book for Snowmass 2001”, American Linear Collider Working Group.

Description of first year project activities

During the first year of funding we will develop the masks/mold for testing foil development with the three processes (photolithography, laser drilling, hot embossing) described above. We will also begin simulations of GEM performance in the forward region of an NLC detector, and work with conjunction with groups interested in GEM technology on prototype trackers.

We request funding for a graduate student working at the Institute for Micromanufacturing on the mask/mold production, travel to the laser drilling facility and to NLC meetings, supplies and materials, machining time, and indirect costs.

Given successful development of foil production techniques suitable for mass production, we foresee requesting additional funding for foil production and detector prototypes in Years 2-3.

Budget

Mask Development:	
Machine Time/IfM Support	$10,000
Materials	$ 5, 000
GEM Foil Development:	
Materials	$ 2,000
Beam-time (CAMD)	- no cost -
Testing and Detector Studies:	
Graduate Student	$14,000
Fringe for student	$ 2,660
Supplies	$ 1,000
Miscellaneous:	
Travel	$ 6,000
Indirect	$ 8,830
TOTAL	$49,490