The Gas Electron Multiplier (GEM) Detector is being used extensively to handle a fairly large flux environment in high energy and related experiments. Due to the ease of operation with environment friendly gases, this detector can be deployed to wider range of experiments as well as in applications to developing the instruments for humanitarian aid purposes. In this talk, we will present results from one such effort. We collaborated with the industry to produce the GEM foils of various specifications and then made an effort to use GEMs as an imaging detector for medical as well as security purposes. The key component of a GEM detector is the GEM foil which has very dense gas-through holes on a 50 μm highly insulating foil (Kapton/PI) coated on both sides with 5 μm layers of copper. Before these GEM foils can be used for assembling the GEM detector the foils electrical and optical properties have to be tested to find defects and correct it. We report on the development of techniques used to study the GEM foils electrically and optically. A feasibility study to utilize GEM detectors for imaging objects with varying densities with x-rays were carried out. The reconstructed images show a good distinction between materials of different densities, which opens the possibility to further explore the applications of GEM detectors to medical imaging or cargo imaging.

**Electrical Behaviour:**
Electrical properties of the GEM foils were tested by measuring its leakage current extended over a period of time in well controlled environment after proper clearing, at various voltages, temperature and humidity. The leakage current insures the proper clearing, defect and stability of the electric field inside holes. Foil has shown impedance of more then 100 Gohm over 550V and remains stable for longer time without any major sparks.

**Optical Inspection of GEM Foils:**
The GEM foil performance depends heavily on the hole geometry and its pattern. A GEM foil with a 140 μm pitch using a hexagonal hole pattern contains approximately 600,000 holes. Any irregularity or defect in the hexagon pattern or in its geometry can profoundly affect their performance. Therefore it’s very important to study foil to locate every glitch and defects which could lead to foil failure. To study these holes, we opt for a digital image processing method, which can be effective and cost-effective. This technique uses a digital microscope to take images and then process them using MatLab (2) image processing algorithm to study holes defects, their diameter, and pitch. The setup is first calibrated using a copper layer as a mask. A thin layer of copper on either side. Several solvents and acid with 5 μm copper foil on both sides of the substrate and the mask is placed on top of the base material and engraved on the photoresist by UV-light exposure. The foil used has a 50 μm Kapton film with 5 μm copper foil on both sides and 5 μc acid baths are used to etch the copper layer to form the copper holes. The polyimide is then dissolved by chemical etching using the copper layer as a mask.

**GEM Foil & Characteristics:**
- Gas Electron Multiplier (GEM): F. Sauli in 1997 (1) introduced a new concept in gaseous detector with micro pattern foil called Gas Electron Multiplier (GEM). GEM foils consist of a 50 μm thin polyimide (Kapton) PI) foil coated with a thin layer of copper on both sides. Bi-conical holes with 50 - 60 μm inner and 70-80 μm outer diameters are chemically etched in the foil at a pitch of about 140 μm by using either a double mask or single mask technique. GEM foils are produced, using photo-lithographic techniques in which hole patterns are transferred to the copper-clad polyimide substrate using microscopic masks placed on the top and bottom of the substrate. A 15 μm thick photo-resistant layer is applied on both sides of the substrate. Copper is patterned on top of the base material and the photoresist is develop by UV exposure. The foil has used a 50 μm Kapton film with 5 μm copper foil on both sides and the mask is placed on top of the base material and engraved on the photoresist by UV-light exposure. The foil used has a 50 μm Kapton film with 5 μm copper foil on both sides and 5 μc acid baths are used to etch the copper layer to form the copper holes. The polyimide is then dissolved by chemical etching using the copper layer as a mask.

**Imaging Using GEM Detector:**
For imaging, we have used a 2D readout board to collect the charge and four DDC24 20 bit 64 channel current input analog to digital converter (ADC) data acquisition electronic board which is capable of taking data at a sampling frequency of 6 kHz and for determining the avalanche produced in this way are collected on readout plane where these charges passed through a DAQ system to amplify, shape and count the signal. The data was then recorded at 22.8 keV of energy for the gain measurement.

**Results:**
- Detector Assembly & Performance: 10cm X 10cm triple layered GEM detector with 3/1/2/1 gaps in mm was assembled and inspected its behaviour by performing following tests:(3)
  - High voltage stress test. This test is done in pure CO₂ flushing at 3 l/h and is a check to withstand high voltage without discharge/sparks or much noise.
  - Spurious rate measurement, which checks signal coming from detector without any actual charged particle or high energy photons interactions.
  - Gain of the detector in Ar/CO₂ (70:30) mixture (3 l/h). Here Ar is ionising gas, with which ionising particle interact and create e/ ion pair. These primary electrons then drift towards three GEM foils, where they experience enough high electric field to create secondary electrons from ionising gas. Three layer of GEM foils act as electron multiplier and the avalanche of electrons produced in this way are collected on readout plane where these charges passed through a DAQ system to amplify, shape and count the signal. The detector was irradiated with X-ray source of 22.8 keV of energy for the gain measurement.

**ABSTRACT**

The Gas Electron Multiplier (GEM) Detector is being used extensively to handle a fairly large flux environment in high energy and related experiments. Due to the ease of operation with environment friendly gases, this detector can be deployed to wider range of experiments as well as in applications to developing the instruments for humanitarian aid purposes. In this talk, we will present results from one such effort. We collaborated with the industry to produce the GEM foils of various specifications and then made an effort to use GEMs as an imaging detector for medical as well as security purposes. The key component of a GEM detector is the GEM foil which has very dense gas-through holes on a 50 μm highly insulating foil (Kapton/PI) coated on both sides with 5 μm layers of copper. Before these GEM foils can be used for assembling the GEM detector the foils electrical and optical properties have to be tested to find defects and correct it. We report on the development of techniques used to study the GEM foils electrically and optically. A feasibility study to utilize GEM detectors for imaging objects with varying densities with x-rays were carried out. The reconstructed images show a good distinction between materials of different densities, which opens the possibility to further explore the applications of GEM detectors to medical imaging or cargo imaging.

**References**

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