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Development of gating foils to inhibit ion feedback using FPC production techniques

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Time Projection Chamber (TPC) with MPGD readout is proposed to be the central tracker of ILD detector for the International Linear Collider (ILC). Positive-ion feedback from the gas-amplification region to the drift region can deteriorate the position resolution of TPC. In order to prevent this from happening, ILC beam-train time structure allow us to use a gate to stop the ion feedback, mounting near MPGD, providing good electron transmission. A GEM foil with many holes, narrow rim and very thin thickness could satisfy these requirements which were learned in previous studies. Our prototype has an insulator thickness of 12.5μm, a hole diameter of 300μm and a hole pitch of 335μm over the TPC-module (170mm x 220mm).
In this study, we have produced this gating foil using the production technology of the Flexible Printed Circuits (FPC) commonly applied to cables inside electrical appliances such as personal computers and cell phones. The miniaturization of these products have forced the development of technologies which allow the production of finer and thinner FPC, along with the progress of the photolithography technology. The standard FPC technology can handle a minimum electrode width of 35μm, depending on the circuit space, and would be applicable to a production of this gating foil.
However, the size of major FPC products is no larger than a few tens of mm, an application to the required size of the gating foil is a significant challenge. In addition, the present conditions of the FPC manufacturing environment, including cleanliness and process-control, are based on the assumption of processing small-sized FPC, much smaller than the module size. Severe adjustment of machining accuracy and quality control is inevitable to produce this gating foil having a enormous density of through-holes with 35μm-width electrodes on the entire surface of the gating foil.
A single-mask process is applied to form a narrow-electrode pattern of the gating foil on one surface of a copper clad laminate. Laser etching of the polyimide insulator is performed using the copper-electrode as the mask, copper on the backside is etched by the standard chemical process. In order to achieve highly uniformed insulator etching over a large area, we use a UV-YAG laser which has high machining accuracy and use it also for making the high taper-angle holes, though its productivity is very low.
We have established a stable process to build the gating foil with optical aperture over 80% for a 100mm x 100mm size. Furthermore, we could also produce finer and higher density electrodes where the hole diameter is 205μm with 225μm pitch for a foil area of 30mm x 30mm. While the production yield of the module size (170mm x 220mm) is limited and unstable mainly due to some contaminations in the present environment.
The precision of pattern and size of area for achievable MPGD using the standard FPC process are also discussed from manufacturer point of view.

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