Development of gating foils using FPC production techniques

Masaru Yoshikai (Fujikura Ltd.)

Collaboration study by ILC-TPC Japanese Group

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Contents

Introduction : Gating foil for ILC TPC

■ Time Projection Chamber for ILC TPC

- International Large Detector (ILD) is used as a particle detector of ILC.
- Time projection Chamber (TPC) with a micro pattern gas detector (MPGD) readout has been proposed as a central tracker.

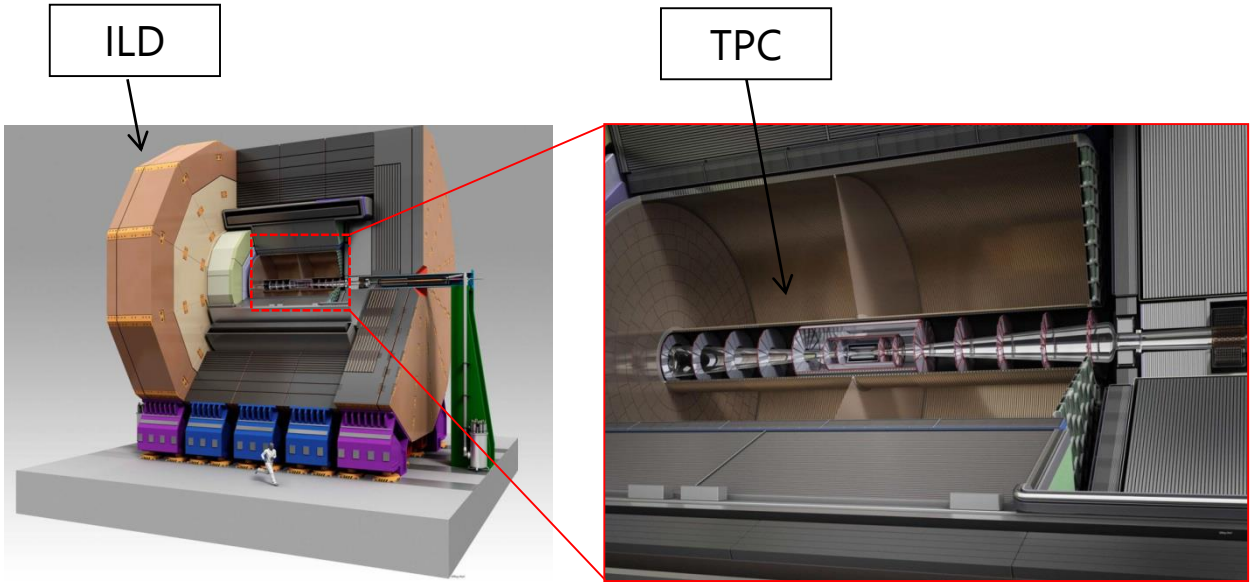


Fig.1-1 Image of ILD

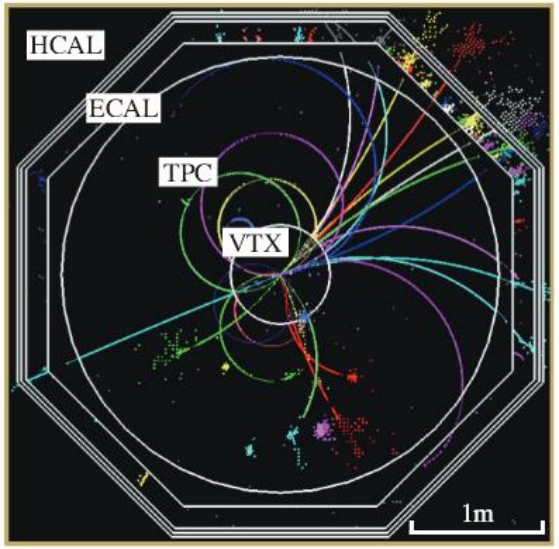


Fig.1-2 Image of particle tracks

Positive ions in TPC reduce point resolution.
→"Ion feedback problem"

"Gating Foil" is a device to solve the ion feedback problem!!

■ Gating foil for ILC TPC

＊GEM : Gas Electron Multiplier

★ Image of gating foil

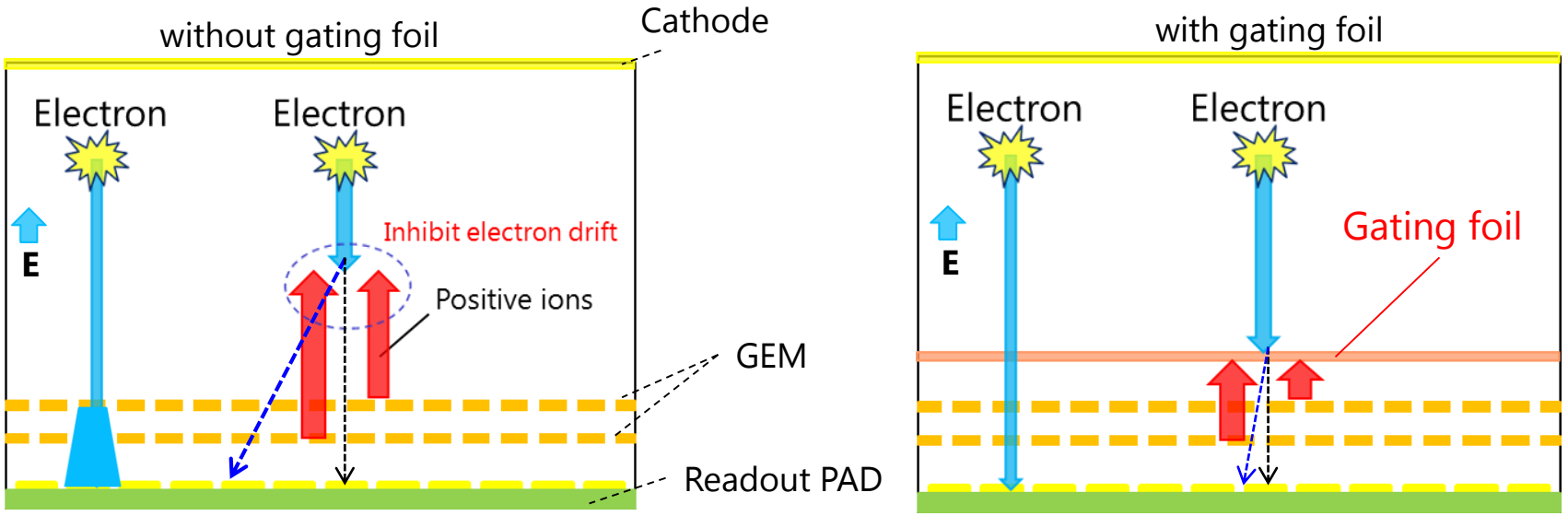


Fig 2. Image of Gating foil in TPC

★ Function of Gating foil

(1) Transmit electrons

(2) Stop the feedback of ions

★ Operation of gating foil

- Operated in low voltage
- Open and close by reversing voltage

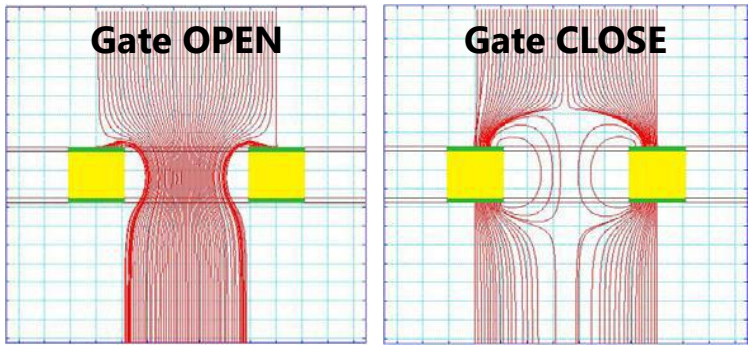


Fig 3. Electric field of gating foil

Requirement for gating foil

- **Requirement for gating foil of ILC TPC**

  -Gating foil has GEM-like structure, but required specs are different.

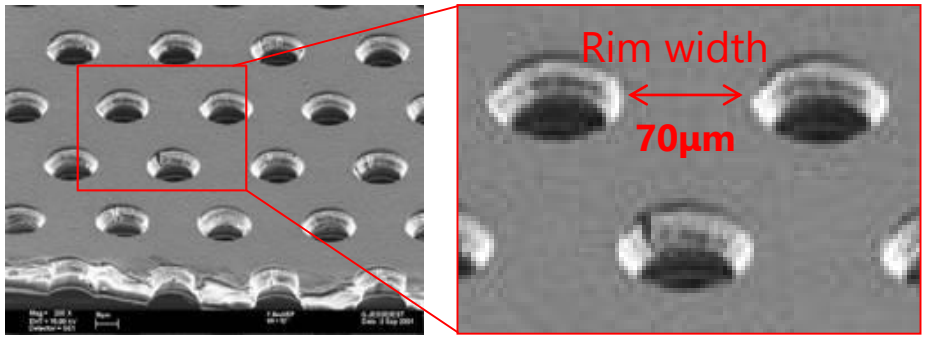


Fig 4-1. Picture of GEM

Item	Amplification GEM	Gating foil
Optical aperture ratio	22.7%	≧80%
Hole size	70μm	≦ 300μm
Hole pitch	140μm	≦335μm
Rim width	70μm	≦35μm
Insulator thickness	50μm or 100μm	12.5μm
Foil size	170mm x 220mm	170mm x 220mm

Table 1. Requirement spec for gating foil and amplification GEM of ILC TPC

Production techniques of FPC and GEM

■ Flexible Printed Circuit (FPC)

- Fujikura is one of major FPC manufacturer in the world.

FPC (Flexible Printed Circuit)

■ Why does Fujikura develop Gating foil?

- GEM is producted by FPC production techniques.
- Difference of production is the mask design on photolithography process.

Key process	GEM production	FPC production
Photolithography	Hole design	Circuit design

Table 2. Production method of FPC and GEM

We think we can apply FPC techniques to gaintg foil processing

Difficulty of gating foil processing

■ Difficulty of Gating foil processing

(1) Very fine structure

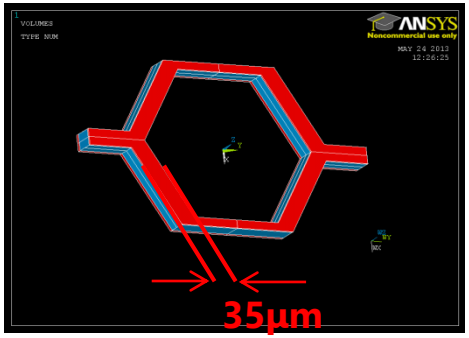


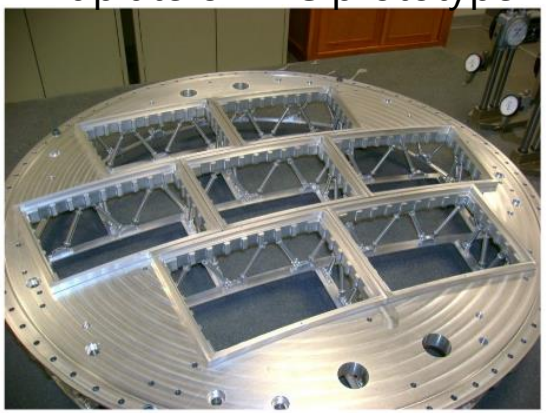
Fig5-1. Hole image of the gating foil

Item	Gating foil
Optical aperture ratio	≧80%
Hole size	≦ 300μm
Hole pitch	≦335μm
Rim width (Hole pitch - Hole size)	≦35μm
Insulator thickness	12.5μm
Foil size	170mm x 220mm

Table 3. Required specs of gating foil

(2) Size is very large

Endplate of TPC prototype



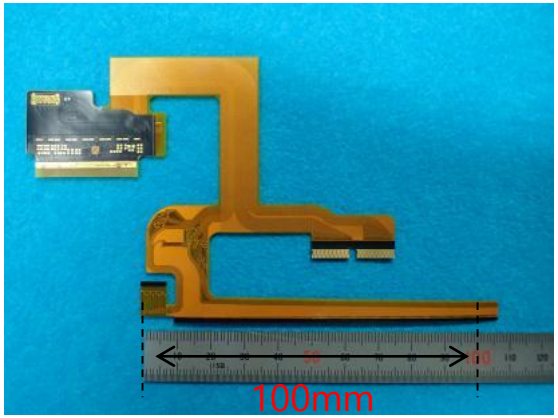


Fig5-2. Size of FPC and Gating foil

Gating foil development is very challenging!!

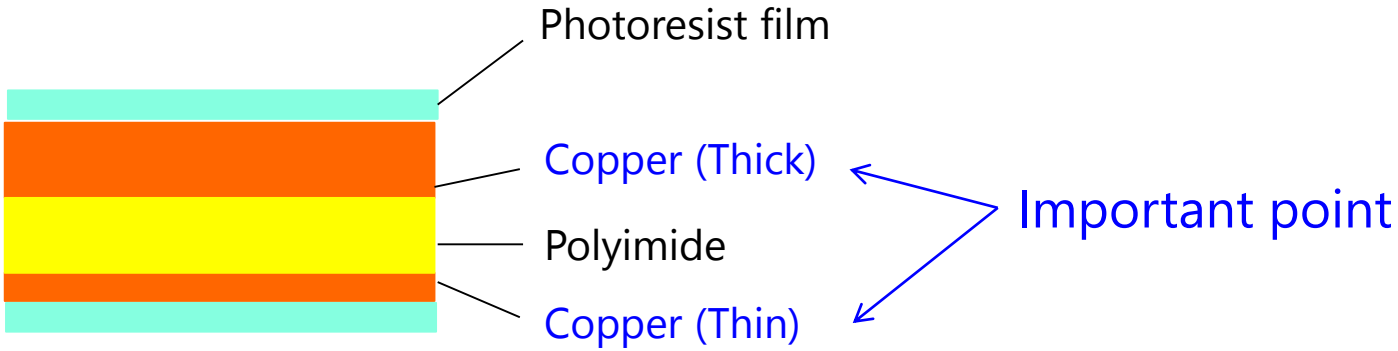
Process of gating foil

■ Process of gating foil

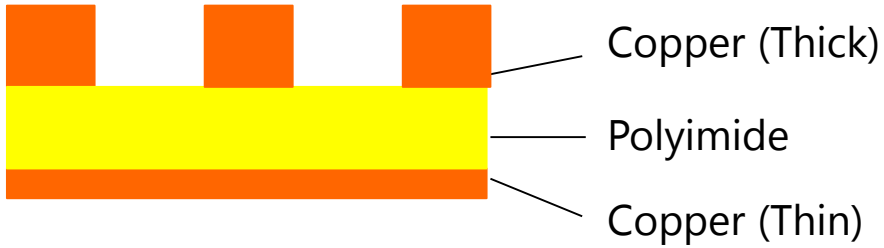
- We tested many process to make the gating foil.

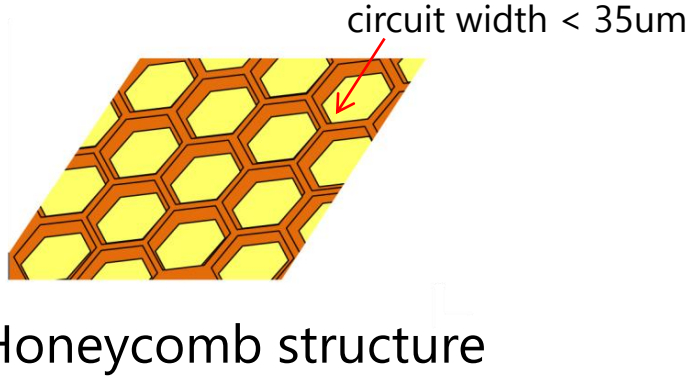
■ Process image

(1) Laminate the photoresist film on copper



(2) Form Honeycomb structure circuit on the thick copper side



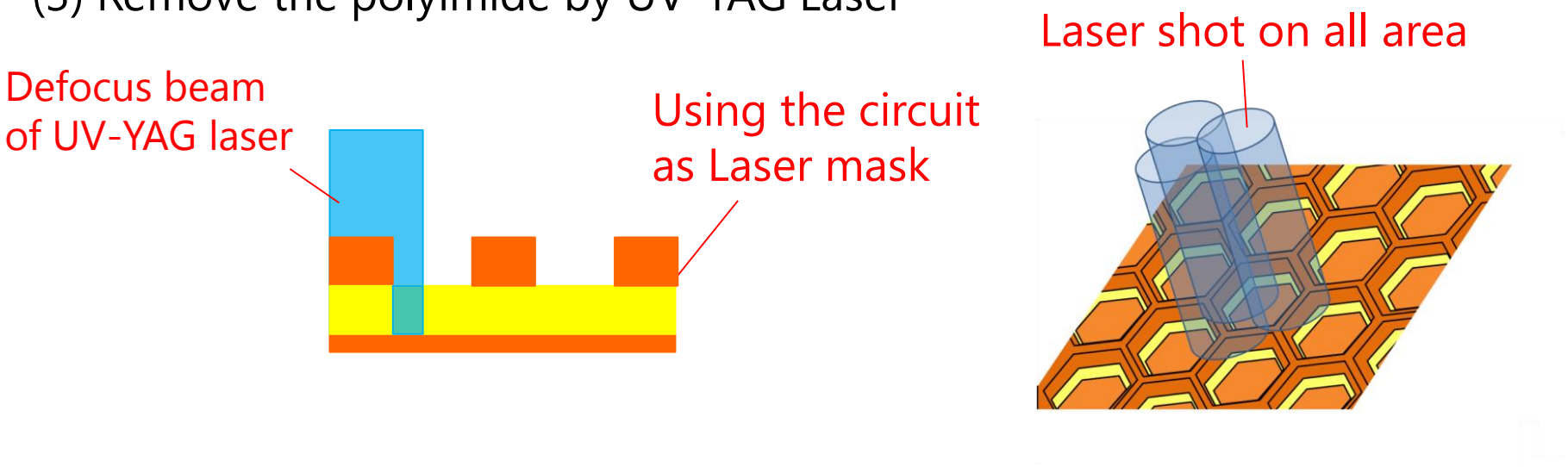


Honeycomb structure

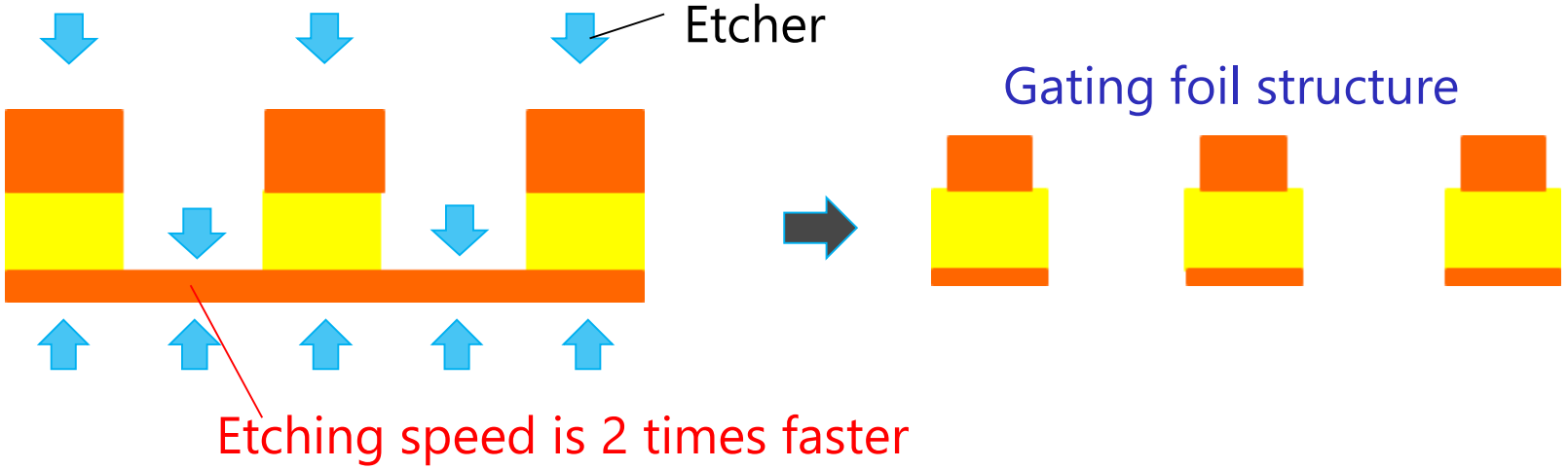
Process of gating foil

■ Process of Gating foil

(3) Remove the polyimide by UV-YAG Laser



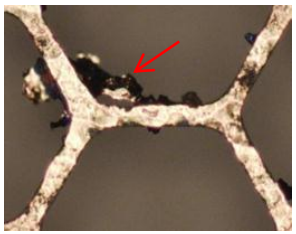
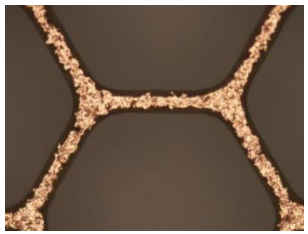
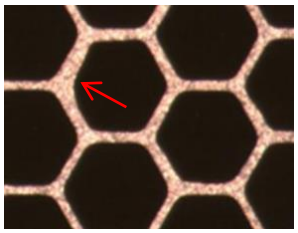
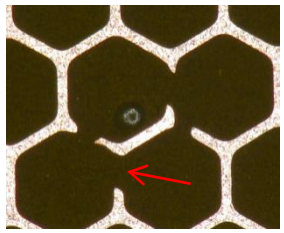
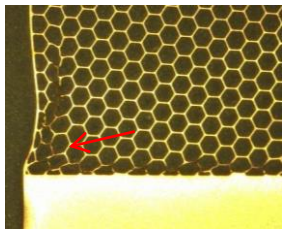
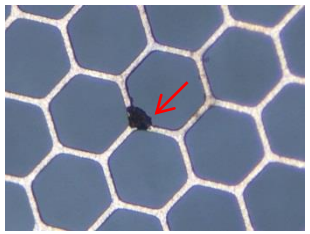
(4) Etch the copper from both side by etching liquid



Development Results

■ Defect of process

【Material problem】 【Process problem】 【Others】

Burr Circuit formation problem Creasing Contamination

■ Completed process

We already solved all problems.

Optical aperture ratio 82.3%

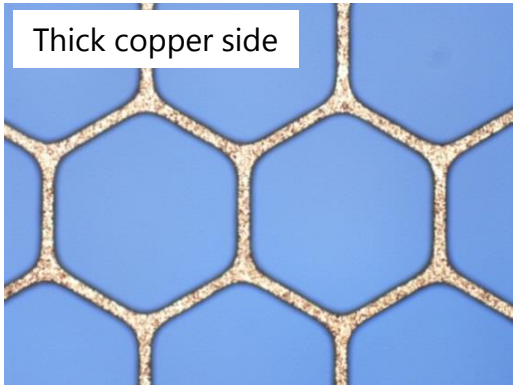
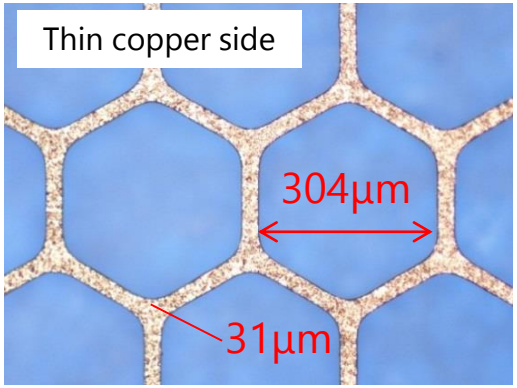


Fig6-1. Apperance of gating foil



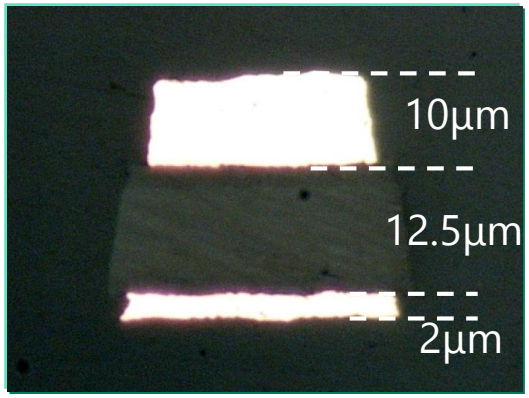


Fig6-2. Cross section of rim

Development Results

(1) ILC-TPC module size (170 mm x 220 mm)

The gating foil with large size is developped by using FPC techniques.

Fig7-1. Gating foil

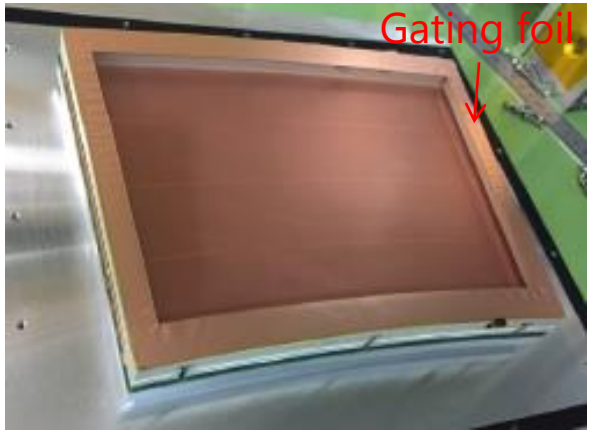


Fig7-2. Gating foil on module

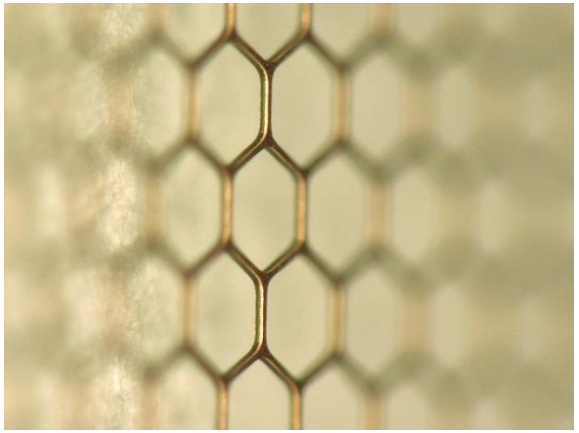


Fig7-3. Magnification of gating foil

(2) Electron transmission ratio

Electron transmission ratio over 80% is conformed by ILC-TPC Group.

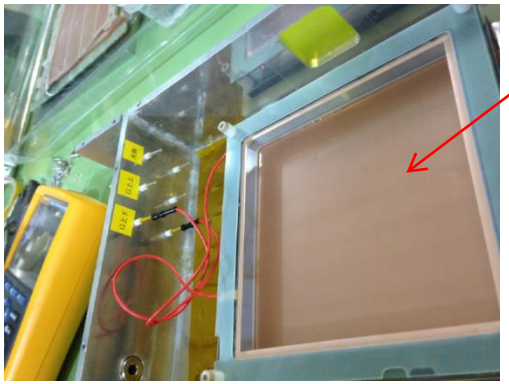


fig7-4. Gating foil on the Test module

please ask the test results to ILC-TPC Group.

- Gating foil development is required to solve the ion feedback problem.
- We tried to develop the gating foil by using FPC techniques.
- We faced many problems in the processing. We succeeded to make gating foil of ILC-TPC module size.

Our New challenge

■ FPC for g-2/EDM experiment

We make FPC for g-2/EDM experiment with collaboration of Kyushu University and KEK.

【Specs of FPC】

(1) Min Line / Space = 35 um/35 um
(2) Circuit Q'ty : 2048 lines
(3) Longest line :
L/S = 40 um/40 um & 200 mm
(4) FPC Size : 100 mm x 270 mm
(5) Structure : Combine 2 FPCs

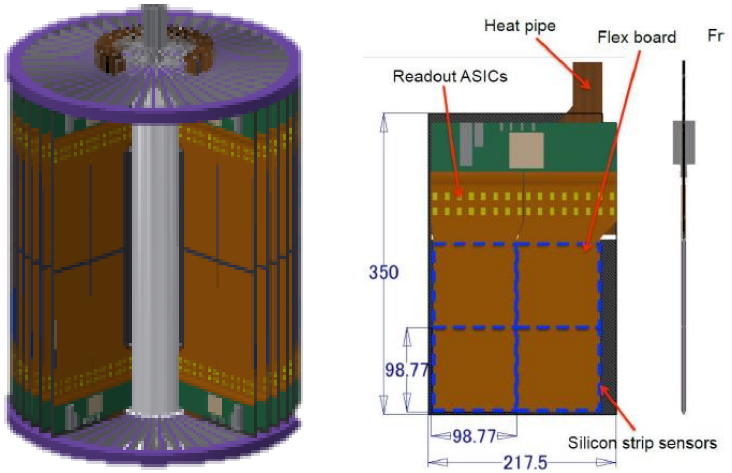


Fig8-1. Detector of g-2/EDM experiment

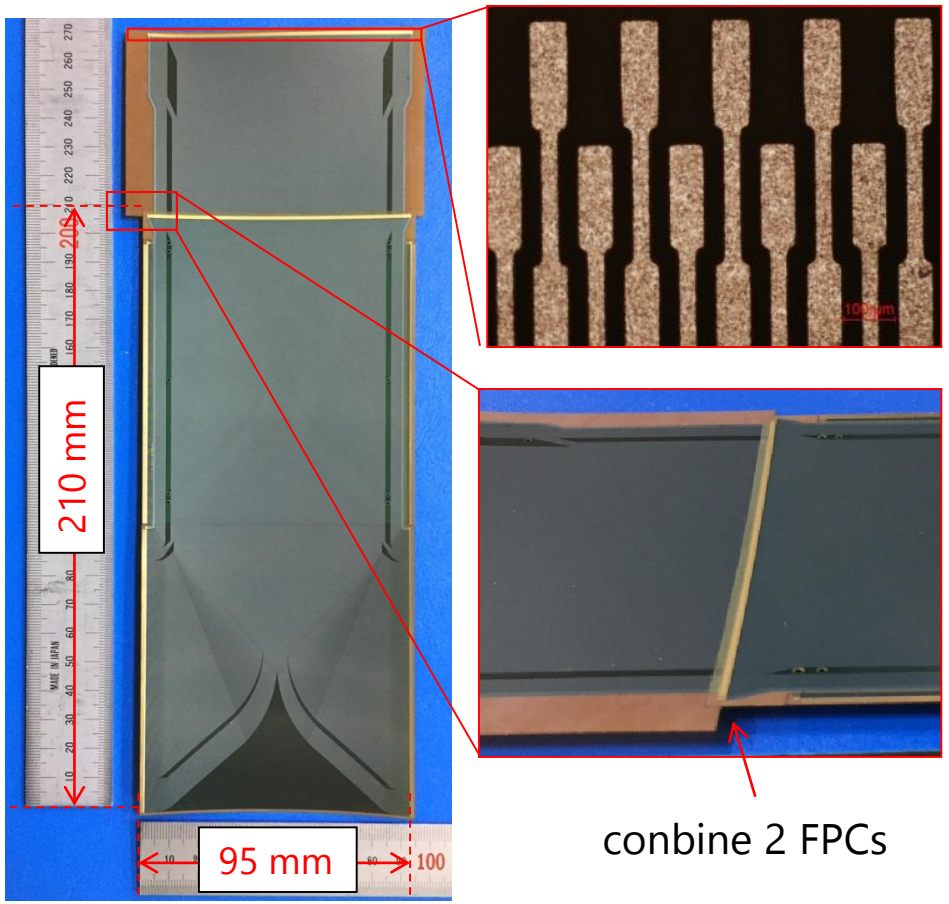
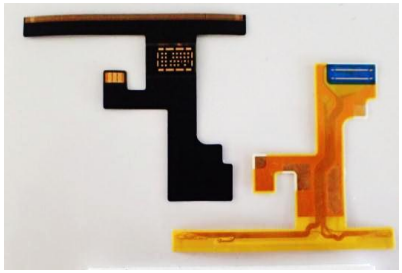
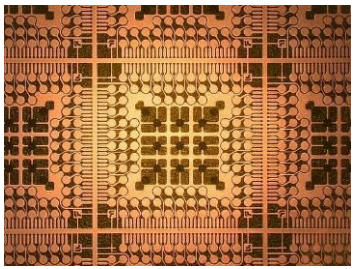


Fig8-2. Characteristics of FPC for g-2 experiment

■ Multi-layer

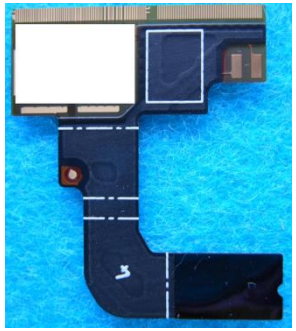


■ Fine pitch



■ Heat diffusing

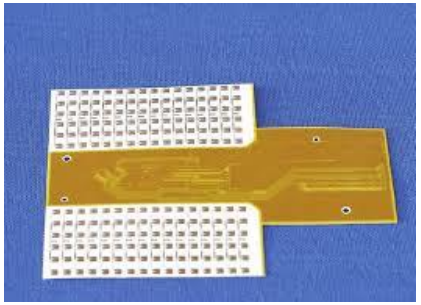
■ Noize sheild



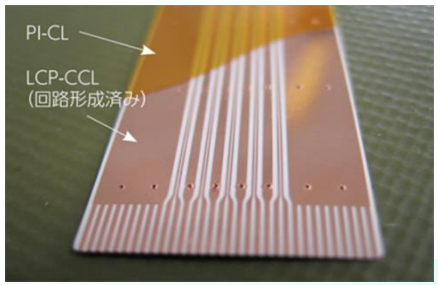
Fujikura

FPC technology

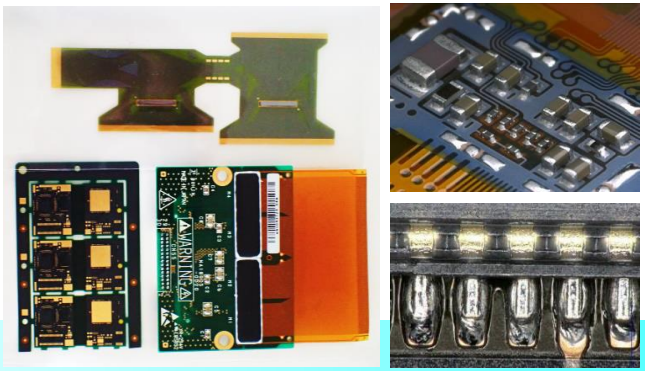
■ Millimeter-wave



■ High-Speed transmission



■ Component Assembly



Back up

Introduction : Positive Ion feedback in ILC TPC

- **Positive Ion Feedback in ILC TPC**

-Positive-ion feedback from the gas-amplification region to the drift region can deteriorate the position resolution of TPC.

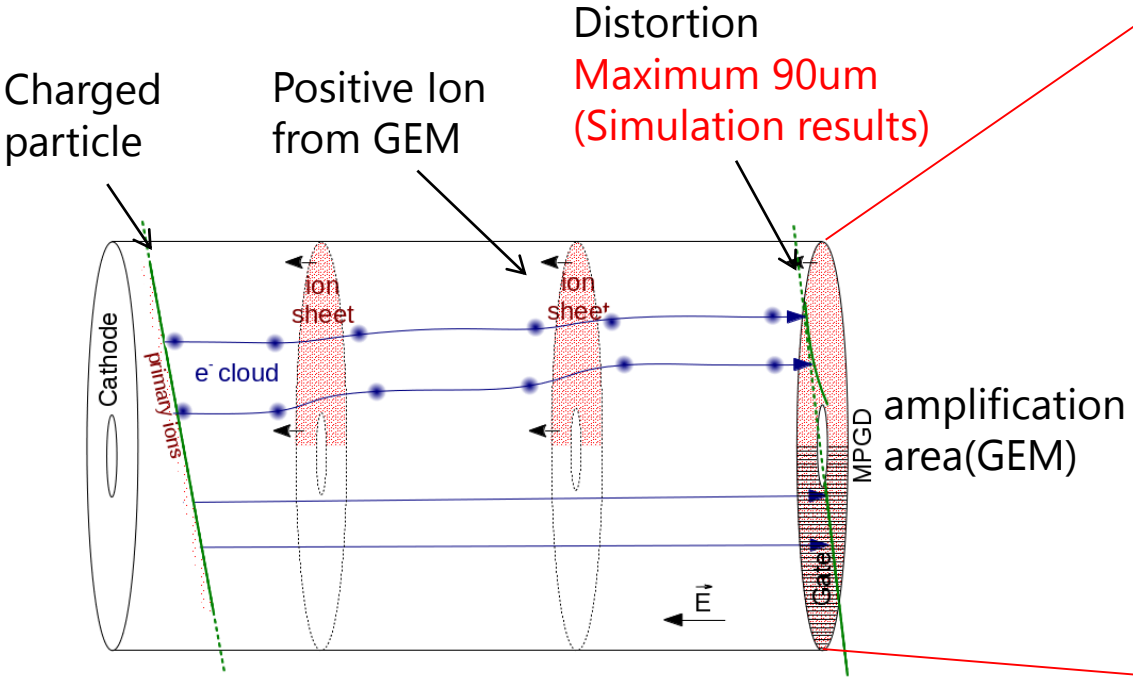


Fig 2-1. Positive ion feedback in ILC TPC

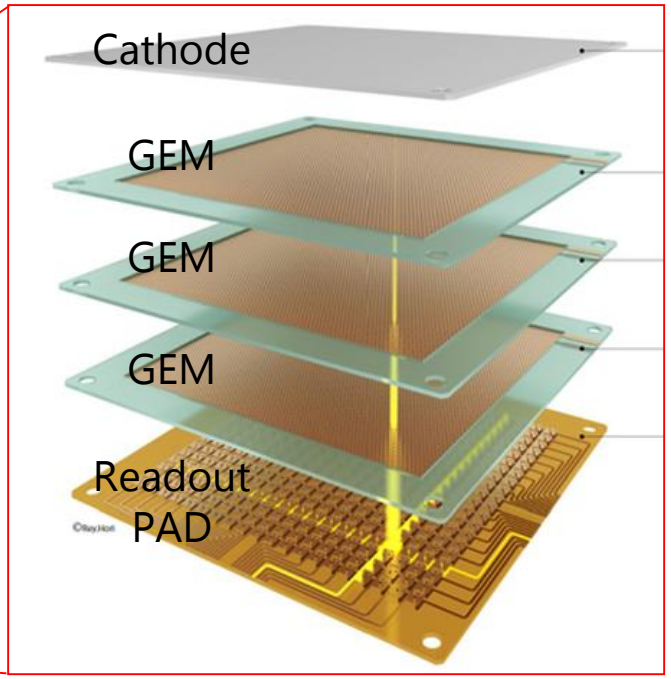


Fig 2-2. Image of ILC-TPC

Required point resolution : better than 100 μm for long drift (~2m)