

Current DLC production centers – JAPAN –

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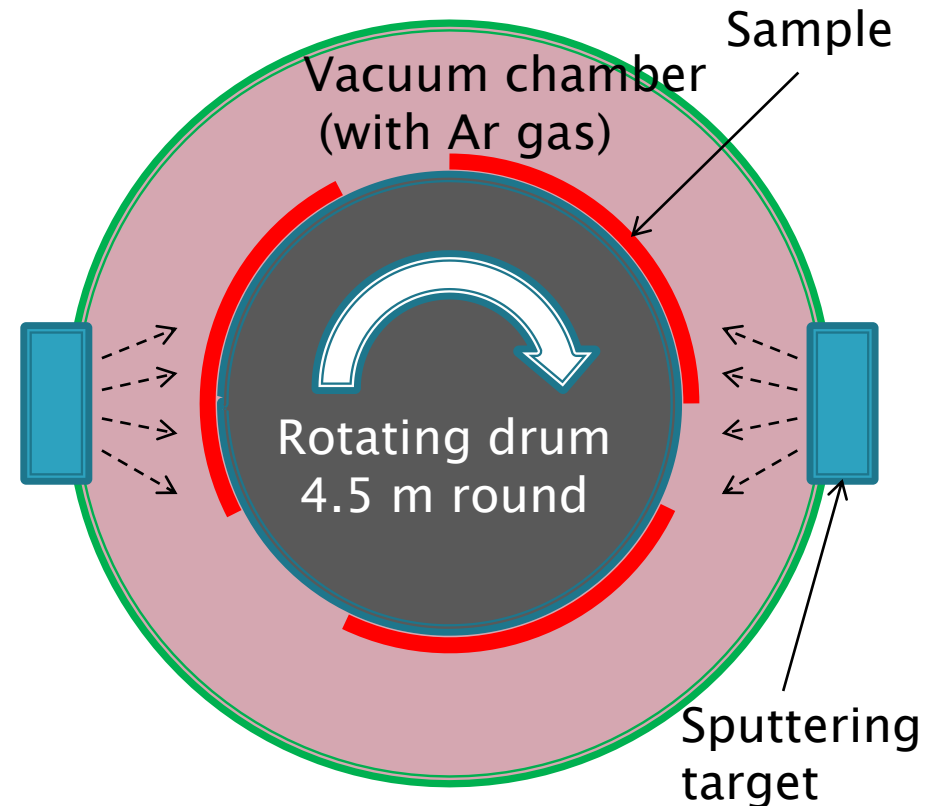
DLC production in JAPAN

- ▶ We have already use industrial process
- ▶ Be-Sputter Co, Ltd., (Industrial company)
 - Their sputtering chamber is made by themselves
 - The sputtering equipment is very large
 - There are several sputtering chambers
- Usually, they are work on metal sputtering
 - For electronics devices, optical devices, surface treatment ...
 - Usually, they have not used carbon for sputtering
 - We have collaborated with Be-Sputter for preparing carbon target and improving C sputter quality.



Sputtering facility in Be-Sputter

- ▶ Large size sputtering is available.
 - 4.5m X 1m
- ▶ Two layer stack sputtering is available
 - Using two separated target
- ▶ Very good uniformity
 - Less than nm size difference, using their special technology



Product of Be-Sputter

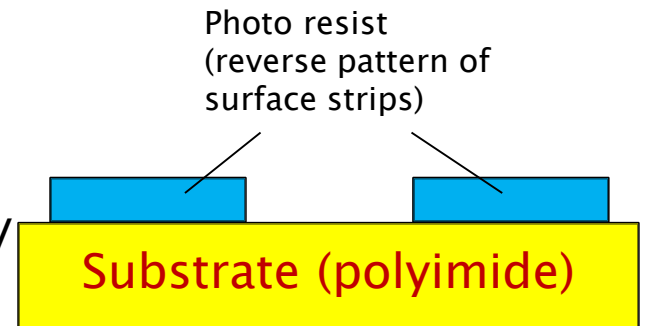
- ▶ ITO transparent conductive film
- ▶ Faraday cage on plastic
- ▶ Etc ...



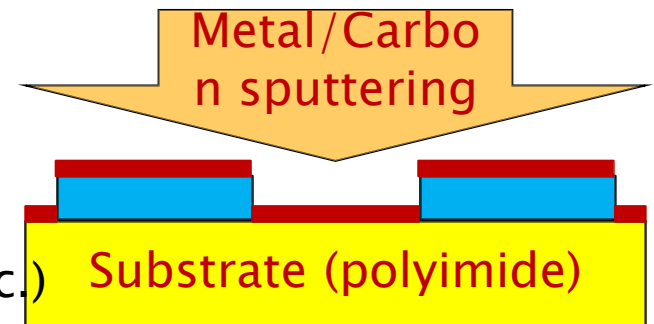
For micro patterning of DLC

- ▶ We need industrial company with PCB process
 - Photo lithography process is needed for making mask of DLC
- ▶ In our case, we used RAYTECH co. ltd. for patterning.

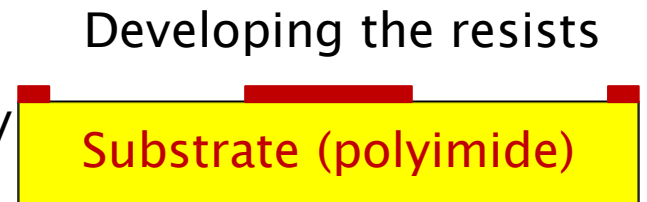
@PCB company
(Raytech inc.)



@Sputtering
company
(Be-Sputter inc.)



@PCB company
(Raytech inc.)



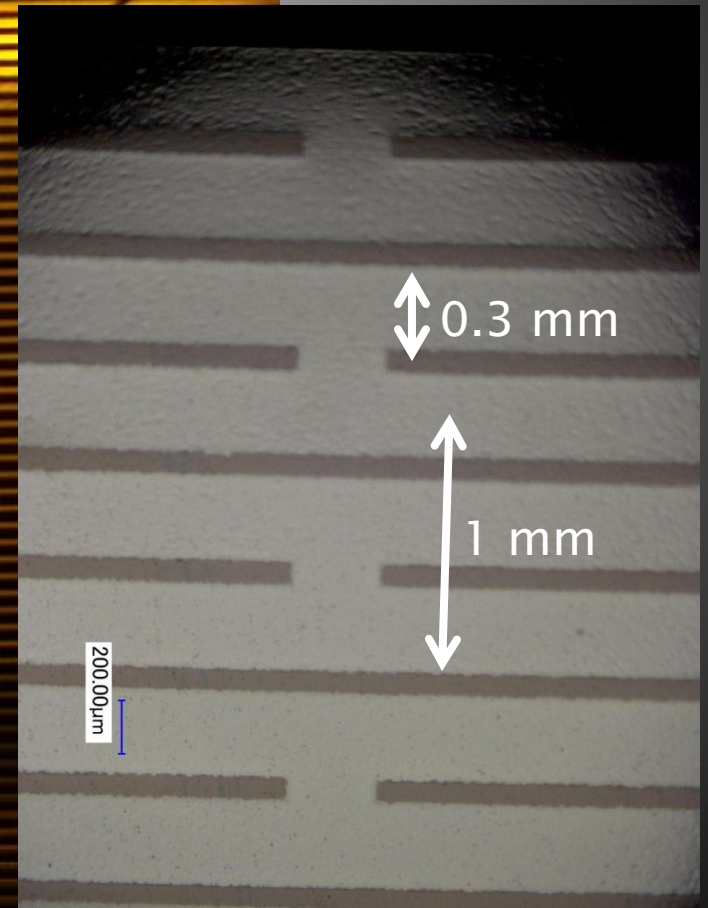
Large resistive strip foil for ATLAS MM prototype

866.4mm

425.3mm

Enlarged picture of resistive strip foil

10 mm



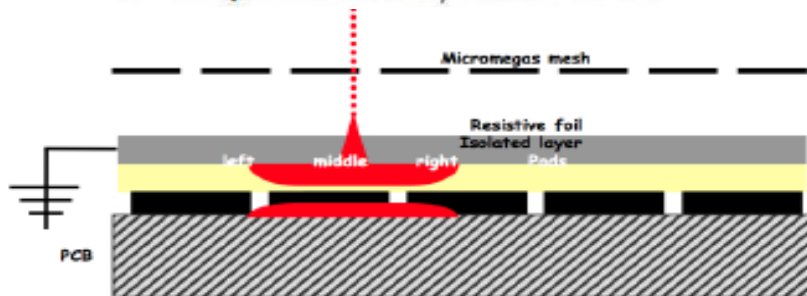
MM with DLC for charge spread

- ▶ DLC MM for ILC-TPC / T2K-TPC readout (P. Colas, D. Attie)
 - The RC continuous circuit evenly spreads the charge, allowing sharing between neighbouring pads

$$\rho(r, t) = \frac{RC}{2t} \exp\left[-\frac{-r^2 RC}{4t}\right]$$

R- surface resistivity

C- capacitance/unit area



MPGD2019
P. Colas, May. 2019

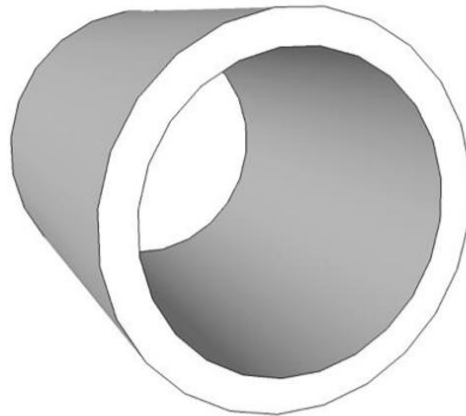
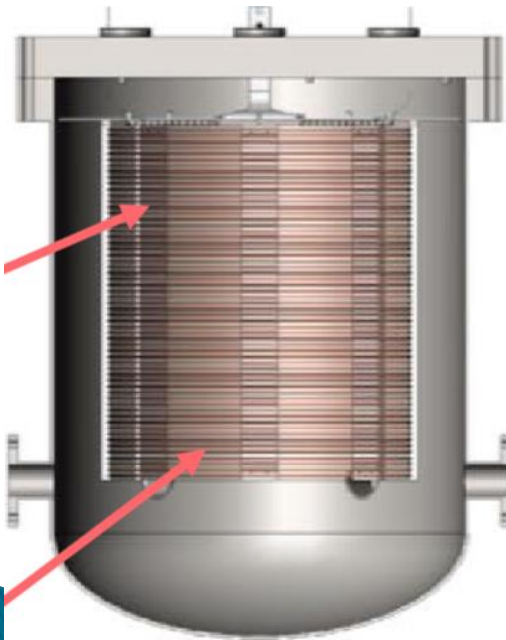
TPC field cage for PANDA X-III

XeSat 2018

T. Simantathammakul, Sep. 2018

ALTERNATIVE FIELD SHAPING DESIGNS

- From this design, there are amount of wasted xenon
 - To solve this problem, we proposed **DLC sputtered on acrylic cylinder**



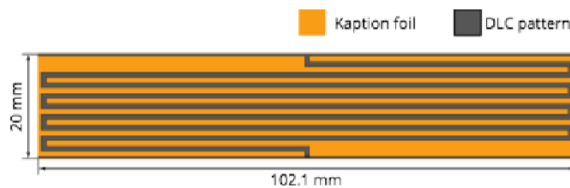
- This design can minimize amount of wasted xenon
- DLC properties
 - High resistivity
 - High Hardness
 - Low friction coefficient
 - Large area is available
- **But DLC sputtered on acrylic is not homogenous**

Design of DLC pattern for field cage

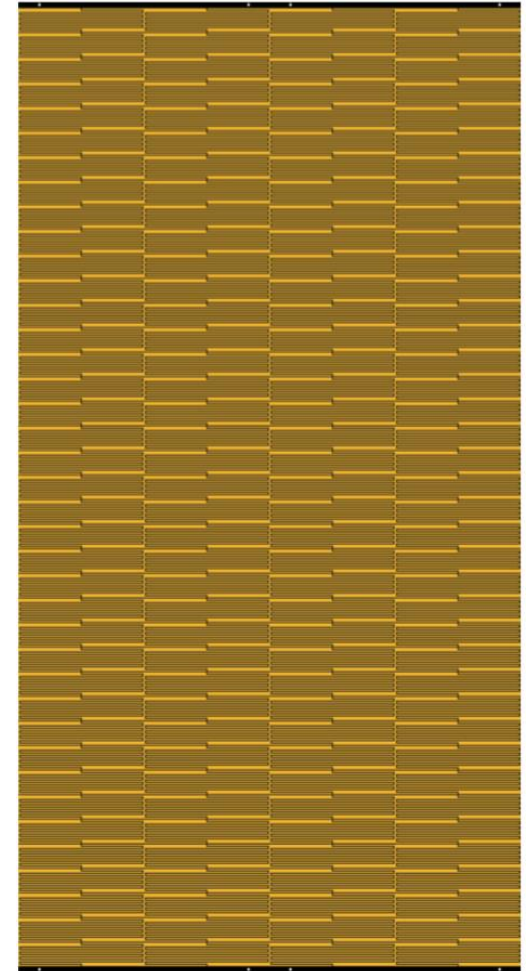
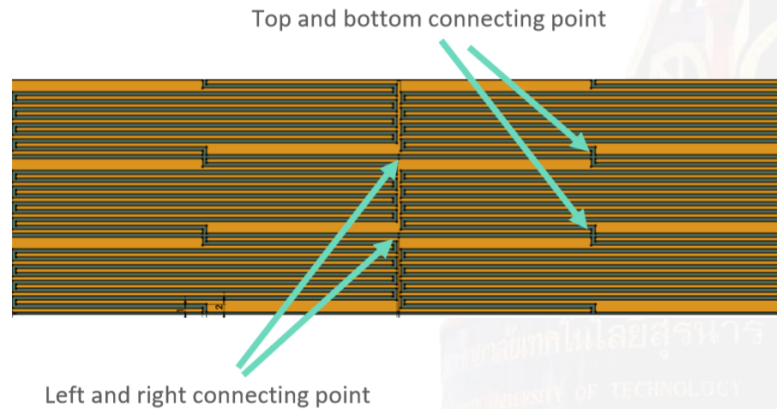
DESIGN OF DLC PATTERN



- Prof. Oshi proposed to design the continuous DLC surface by a mosaic of patterned cell

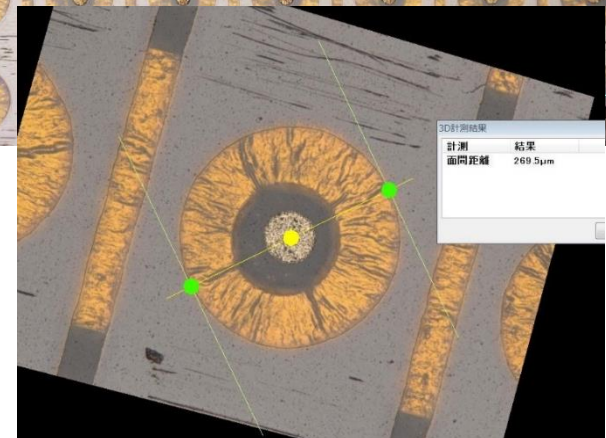
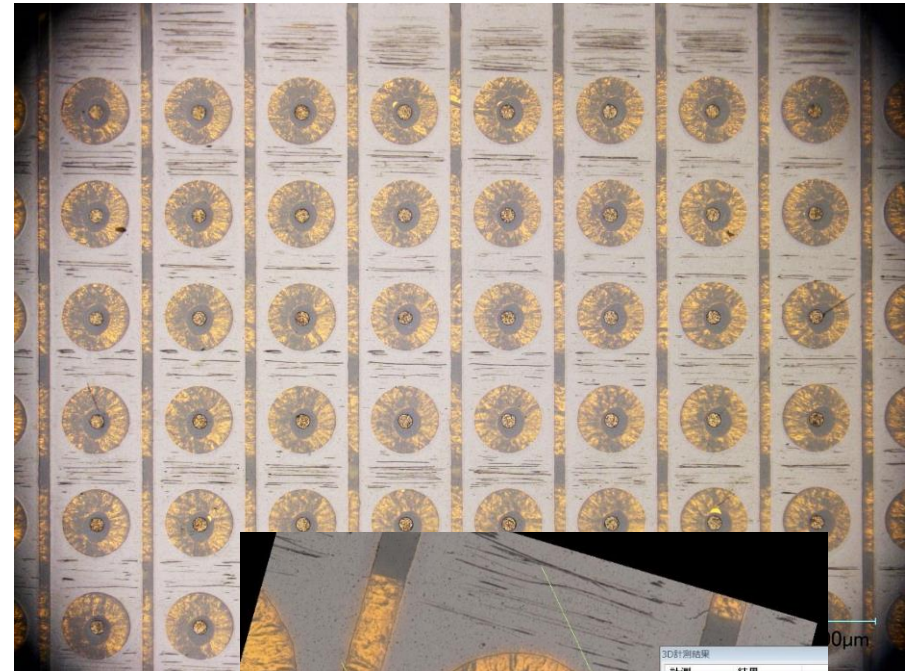
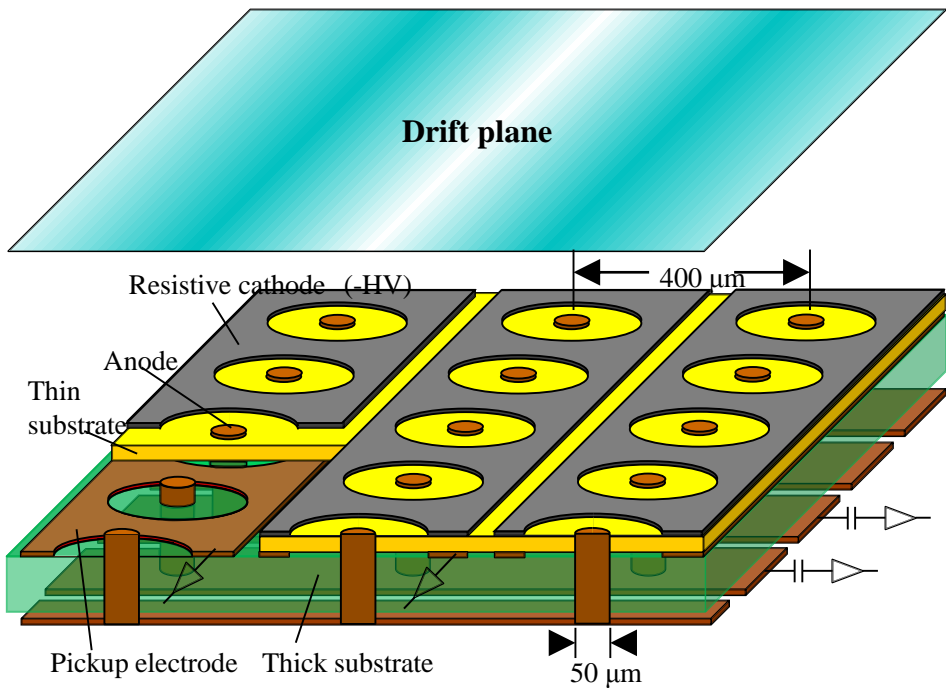


- Each cell is about 10.2 cm wide and 2 cm high
- And contains a trace of 1 mm wide DLC meandering from one end to the other



DLC for surface electrodes in μ -PIC

- ▶ Fine patterning ... μ -PIC with resistive cathode (2013 - now)

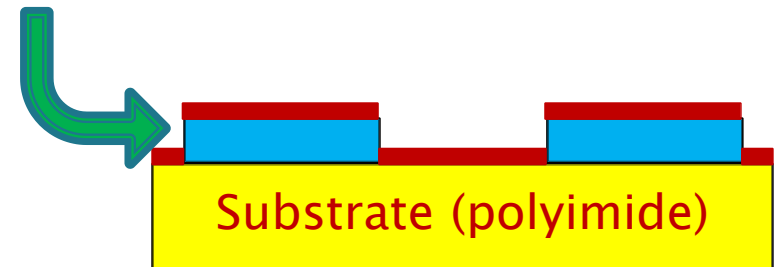


Details will be shown in this afternoon

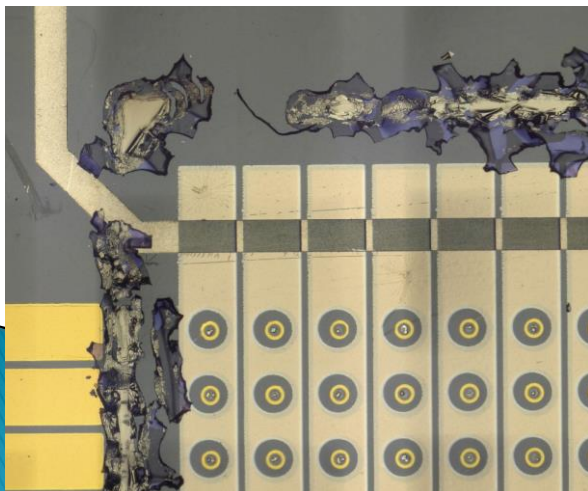
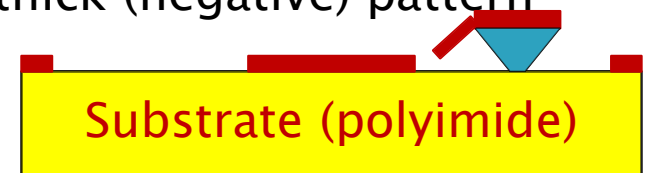
The problem in liftoff method

- ▶ The etching for remained resist is effected only from side
- ▶ For large area ($> 5\text{mm}$) of masked area, those mask cannot be removed
 - \rightarrow DLC remained

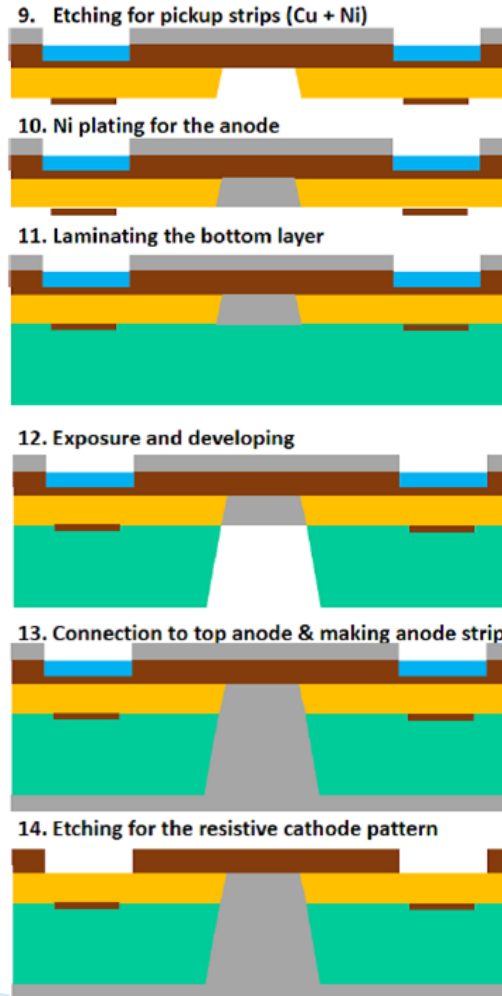
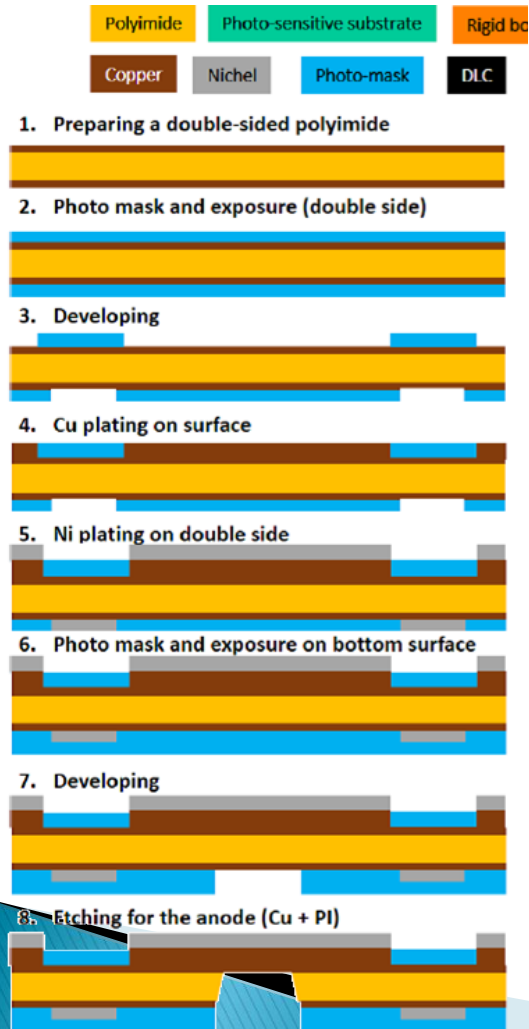
Etching the resist from side



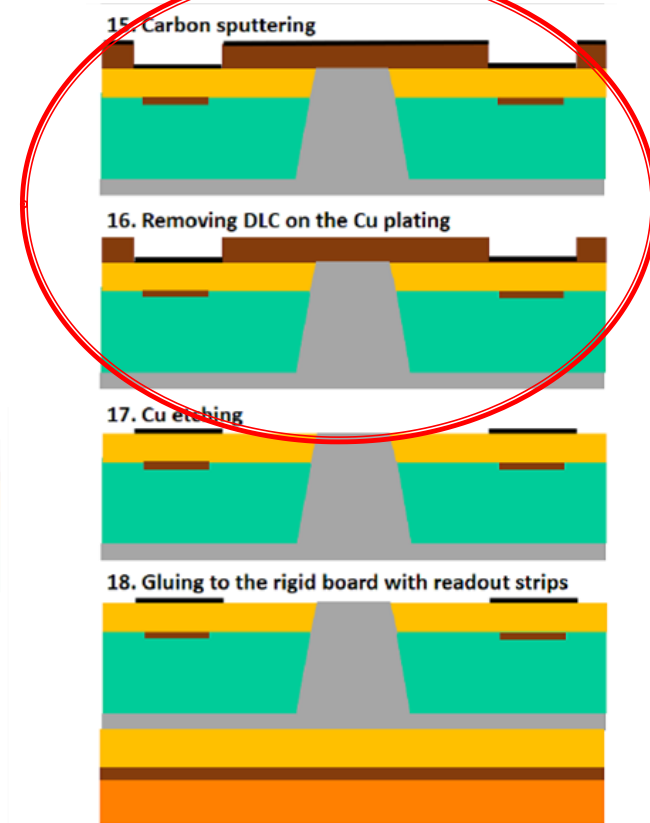
DLC and resist can be remained
In thick (negative) pattern



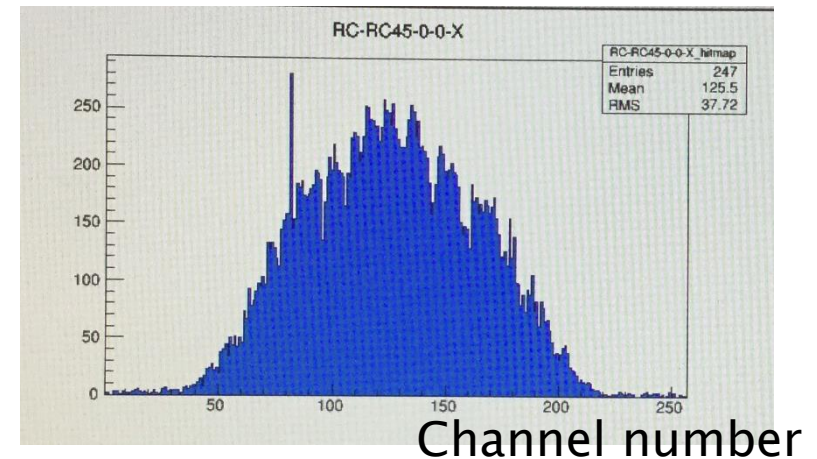
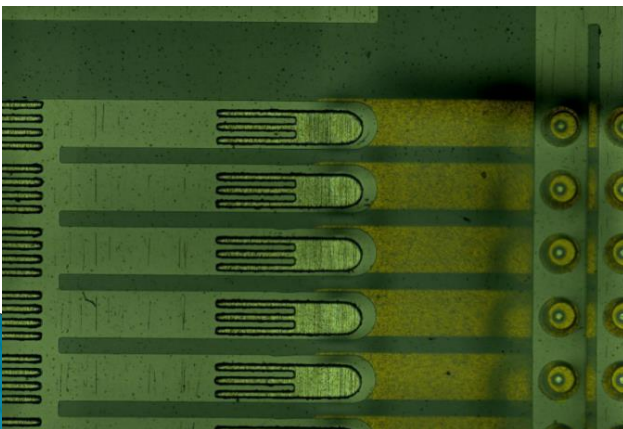
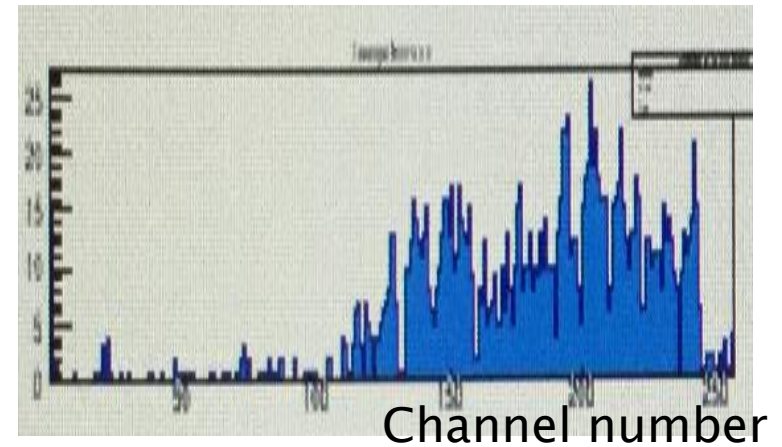
Manufacturing process of resistive m-PIC (2017-2018)



Liftoff using metal



Signals with / without zigzag connection (HV bias)



Summary

- ▶ DLC for MPGDs are produced in JAPAN using industrial companies (Be-Sputter)
- ▶ Large size (maximum 1 m x 4.5m) DLC foils can be produced
- ▶ Fine patterning of DLC is also available using liftoff method
 - By using resist or metal etching
- ▶ Large resistive DLC foils are provided (almost) commercially. It cost around 3k EUR / 1 batch.
 - The costs will be reduced for multi batch in one time.