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.
Large resistive strip foil for ATLAS MM prototype

866.4mm

425.3mm
Enlarged picture of resistive strip foil

10 mm

0.3 mm

1 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

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

R- surface resistivity
C- capacitance/unit area

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MPGD2019
P. Colas, May. 2019
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

Top and bottom connecting point

Left and right connecting point

XeSat 2018
T. Simantathammakul, Sep. 2018
DLC for surface electrodes in $\mu$-PIC

- Fine patterning ... $\mu$-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 (> 5mm) of masked area, those mask cannot be removed
  - → 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)

1. Preparing a double-sided polyimide
2. Photo mask and exposure (double side)
3. Developing
4. Cu plating on surface
5. Ni plating on double side
6. Photo mask and exposure on bottom surface
7. Developing
8. Etching for the anode (Cu + Pt)
9. Etching for pickup strips (Cu + Ni)
10. Ni plating for the anode
11. Laminating the bottom layer
12. Exposure and developing
13. Connection to top anode & making anode strip
14. Etching for the resistive cathode pattern
15. Carbon sputtering
16. Removing DLC on the Cu plating
17. Cu etching
18. Gluing to the rigid board with readout strips

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 1m 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.