Production and performance study of Diamond-Like Carbon for the resistive electrode in MPGD application

You Lyu, Yi Zhou, Jianbei Liu, Ming Shao, Zhiyong Zhang, Guofeng Song, Xu Wang

State Key Laboratory of Particle Detection and Electronics

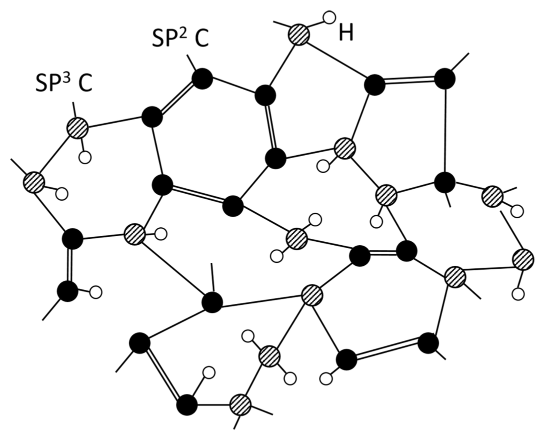
Department of Modern Physics, University of Science and Technology of China

Diamond-Like Carbon (DLC) coatings provide a new method to produce high-quality resistive materials for MGPDs. Many studies on DLC production process of Magnetron Sputtering have been carried out to produce applicable DLC resistive materials for MPGDs. Two resistive electrodes with different structures (DLC/APICAL and Cu/DLC/APICAL) have been produced and tested in Micro-Resistive WELL detectors. THGEMs with DLC coating on dielectric surface to remove the charging-up effect was produced and tested. Application of DLC in Picosecond MicroMegas detector as a robust photocathode is also presented.

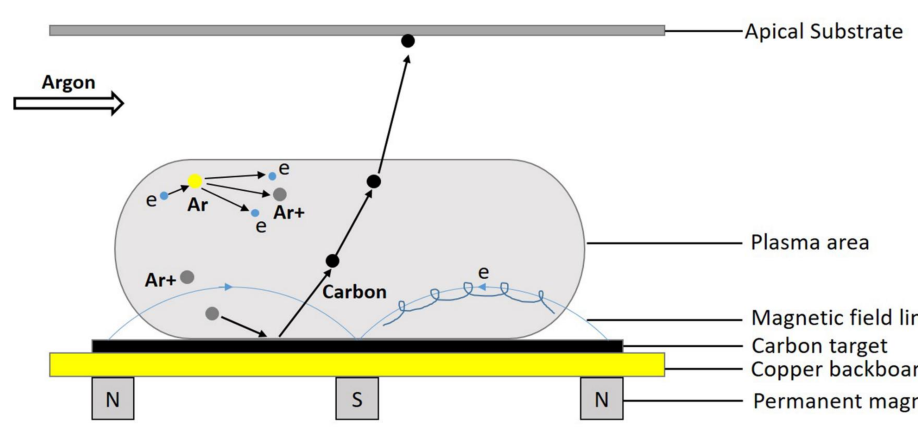
DLC & Magnetron Sputtering

Diamond-like Carbon (DLC): a class of metastable amorphous carbon material, first applied as resistive material in MPGDs by Atsuhiko Ochi [1].

Magnetron Sputtering: an effective way for DLC coating at low-temperature.



Atom structure of DLC



Schematic of magnetron sputtering technique

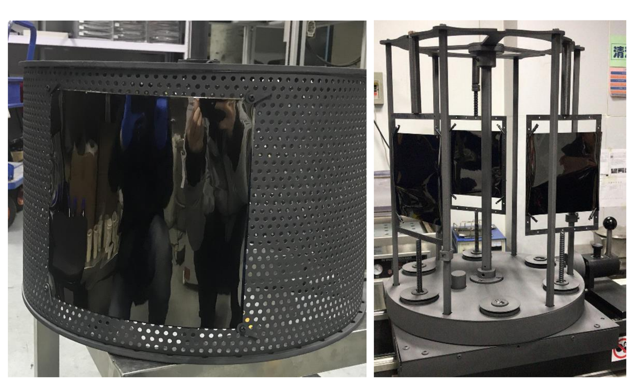
DLC coating:
Good adhesion & Stability

Magnetron Sputtering:
Accurate surface resistivity
Uniform thickness

Teer 650

Hauzer 850

DLC samples



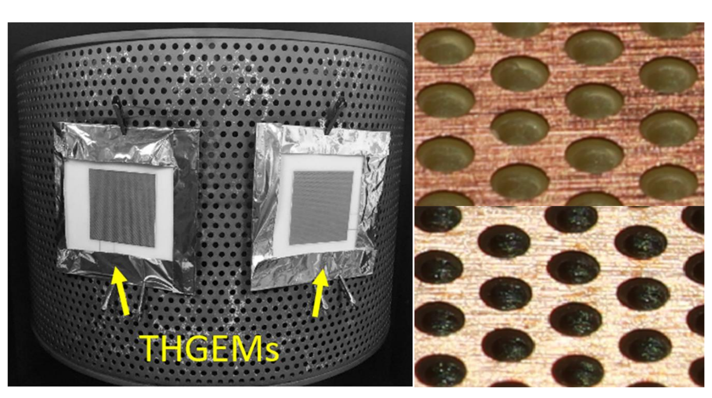
DLC/APICAL (Single & double side)

Cu/DLC/APICAL

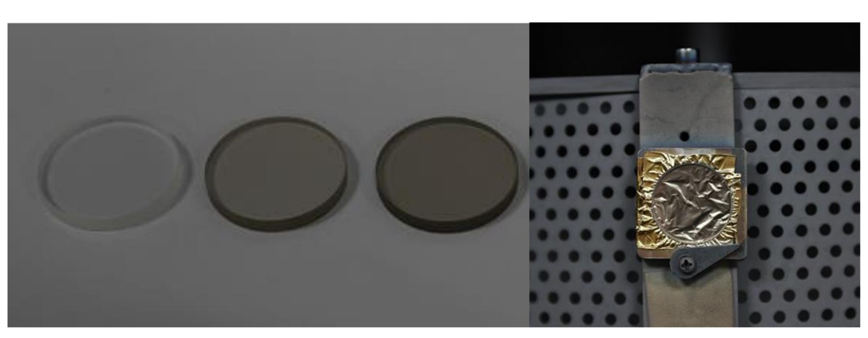
Copper covered DLC:

- Chromium: ~10 nm
- Copper: ~ 4.3 μm

Chromium is used to improve the adhesion between DLC and copper.



DLC-THGEM



DLC for Radiation-hard photocathode

3 mm MgF_2 + DLC (different thickness)

Special thanks to LICP for technical support of the DLC coating

Characterization of DLC

Surface resistivity: MΩ-GΩ

- Sensitive to iC_4H_{10}
- More precise by controlling the thickness

Uniformity:

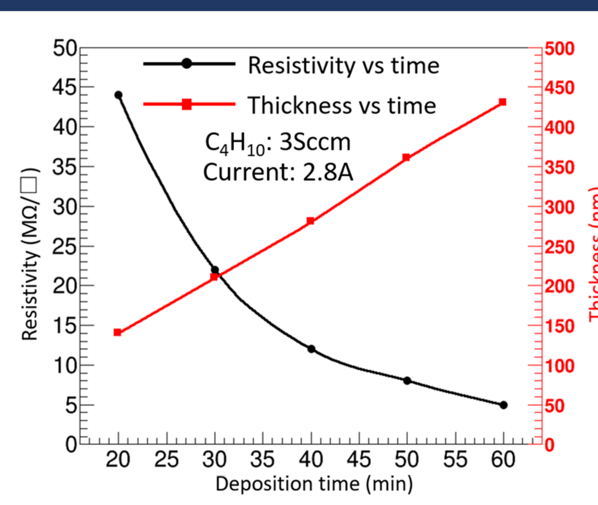
~15% @15cm×15cm sample

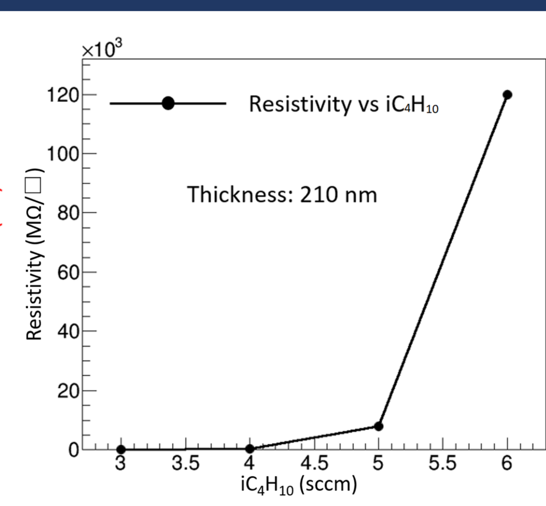
~23% @25cm×25cm sample

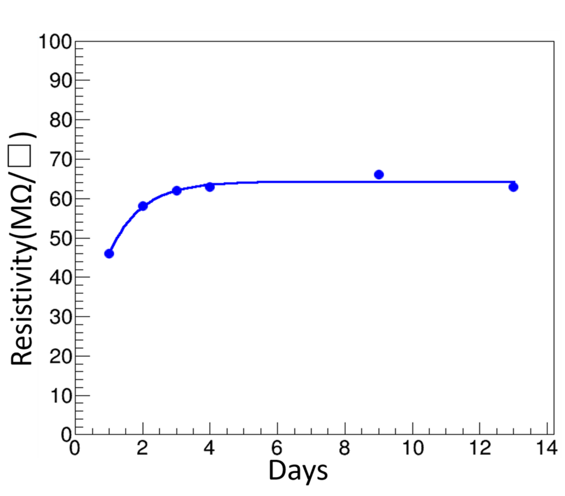
Stability:

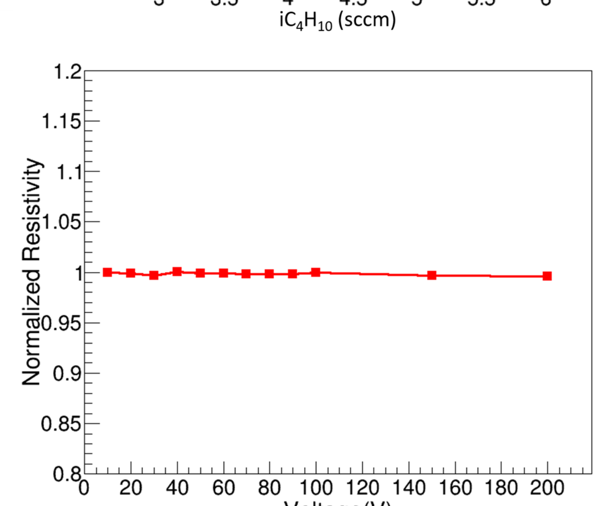
Increase 30% in the first 4 days and stayed stable.

Independent with the voltage, showing ohmic behavior.









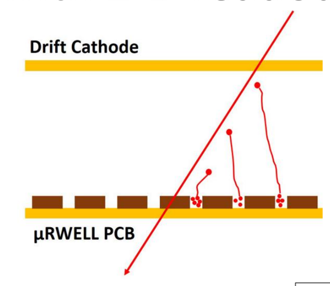
Application1: μRWELL with 2-D readout

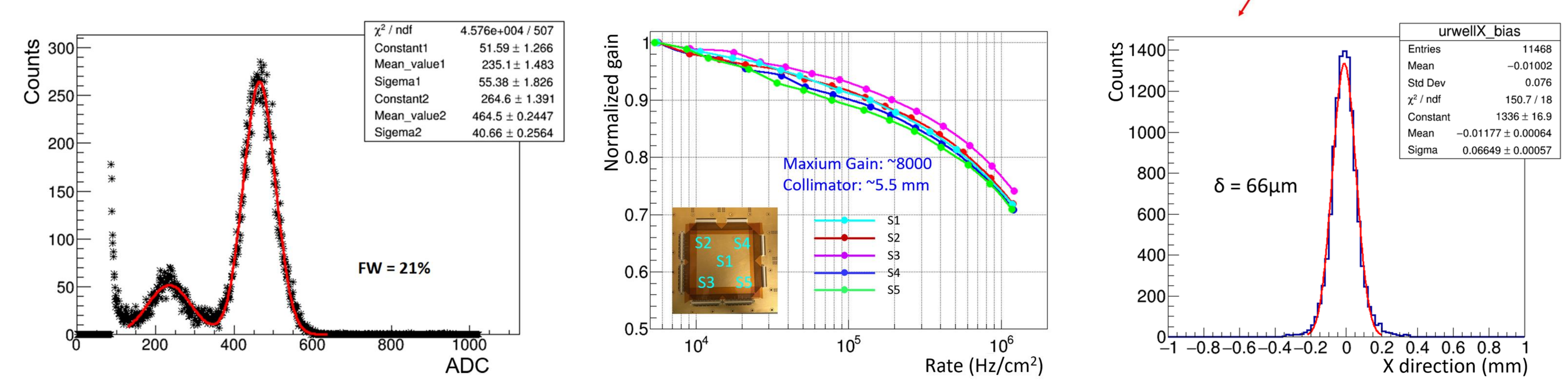
μRWELL [2] prototype based on DLC-coated APICAL foil with 2-D readout

Energy resolution: ~21%@8 keV X-rays

Rate capability: gain drop<10% @100kHz/cm²

Spatial resolution: <70 μm @150-GeV/c muons





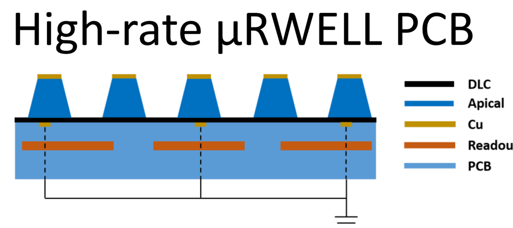
Special thanks to Rui De Oliveira and Antonio Teixeira for supplying the μRWELL PCB

Application2: High-rate μRWELL

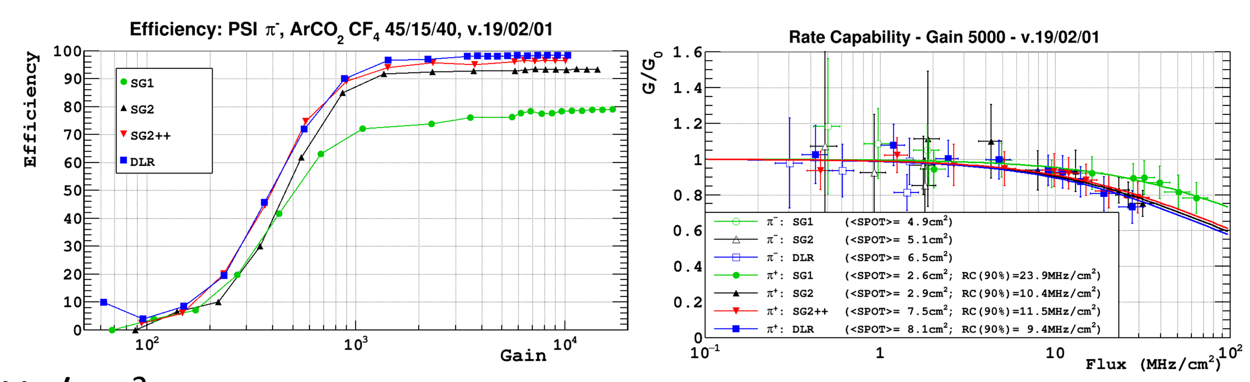
High-rate μRWELL based on the combined structure of DLC resistive electrode

SILVER-GRID 2++ μRWELL: The copper clad on the DLC is etched to dash strips and grounded at every a few mm.

High-rate μRWELL PCB



- Efficiency: 97%
- Gain drop <10% @5 MHz/cm²

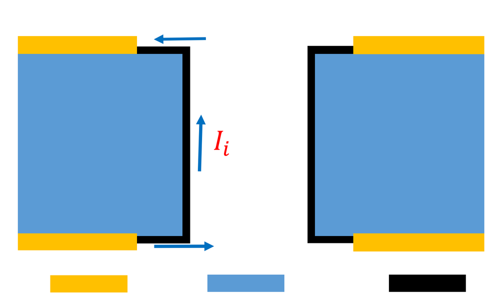


Courtesy of G. Bencivenni & DDG-LNF group

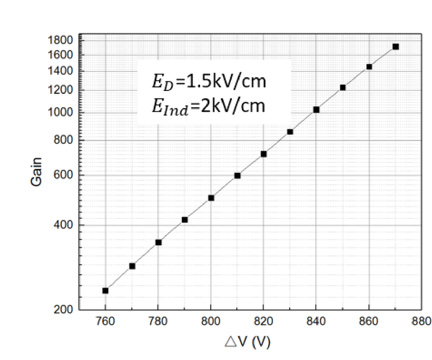
High space resolution μRWELL for high-rate applications G.Bencivenni – Plenary session 19/2/2019

Application3: Charging-up free THGEM

DLC-THGEM: coating DLC on THGEM dielectric surface



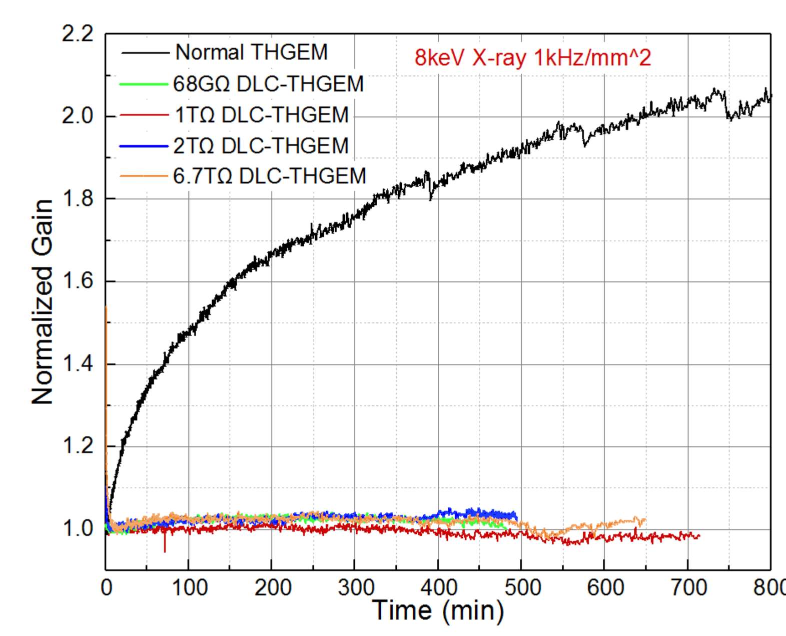
DLC-THGEM



Gain vs voltage

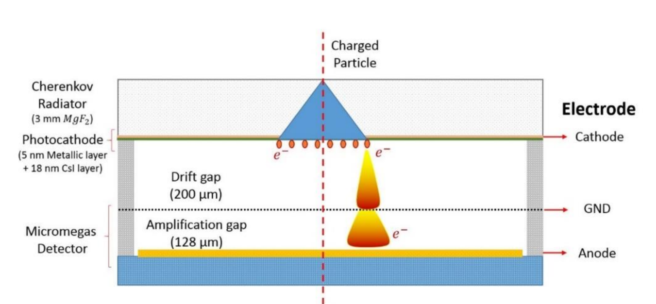
The time evolution of gain of DLC-THGEM with different resistance were tested.

✓ Long term charging-up effect removed.

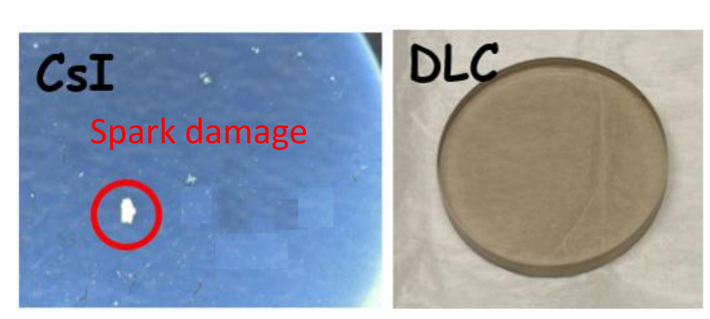


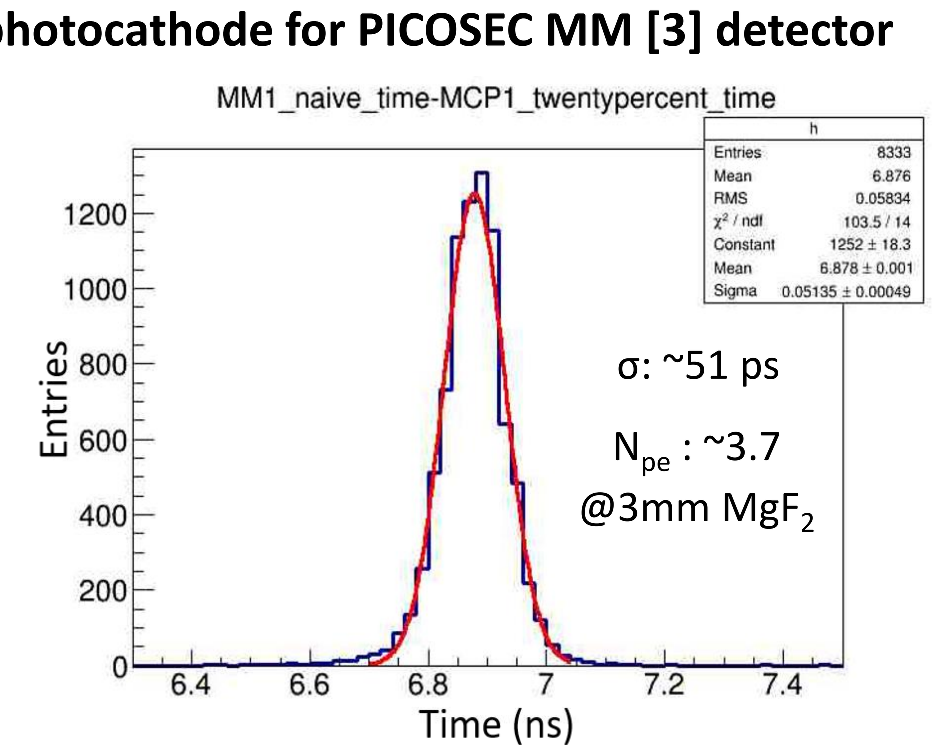
Application4: Radiation-hard photocathode

DLC: applied as the radiation-hard photocathode for PICOSEC MM [3] detector



PICOSEC MM detector





σ: ~51 ps

N_{pe} : ~3.7 @3mm MgF_2

Summary

1. Performance and production process of DLC, as high quality resistive materials, have been studied based on magnetron sputtering technique.
2. The characterization of a two-dimensional readout μRWELL and high-rate μRWELL based on DLC resistive electrode are performed.
3. The DLC-THGEM for charging-up free and DLC for radiation-hard photocathode in PICOSEC are presented too.

[1] Ochi A. Carbon sputtering technology for MPGD detectors[C]//Technology and Instrumentation in Particle Physics 2014. SISSA Medialab, 2015, 213: 351.

[2] G. Bencivenni et al. The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD. Journal of Instrumentation 10.02 (2015): P02008.

[3] J. Bortfeldt , et al. "PICOSEC: Charged particle timing at sub-25 picosecond precision with a Micromegas based detector", Nucl. Instru. Methd A, 903 317 2018