Progress of DLC Resistive Electrode

You LV

On behalf of resistive DLC collaboration

State Key Laboratory of Particle Detection and Electronics
University of Science and Technology of China

RD51 mini week, 05-12-2018

Outline

- R&D on thick-DLC
- Application of thick-DLC
- Copper coating on DLC

Motivation

Current thin-DLC sample

Thickness : ~ 50 nm
Surface resistivity: 1 MΩ/□ to 100 MΩ/□
Resistivity uniformity: ~13% @15cm×15cm DLC

The current thin-DLC sample have been successfully applied in μRWELL detector as resistive electrode.

Thick-DLC sample

Thickness : > 100 nm
Surface resistivity: ~MΩ/□ to ~TΩ/□
Resistivity uniformity: ~23% @25cm×25cm DLC

Thick-DLC can be applied in many MPGDs due to the thicker DLC coating with a wide range of adjustable surface resistivity.

- The longer of the deposition time, the DLC is thicker and has a lower resistivity.
- Add hydrogen into the DLC can increase the surface resistivity significantly.
- Add hydrogen into the DLC by using the Ar/iC_4H_{10} gas mixture.
- The higher isobutene flow, the higher surface resistivity.

More detail of the deposition process can be found in *Y.Zhou, RD51 Collaboration Meeting, 28-09-2017*

Sample of thick-DLC

- The value measured by the tool have a scale factor of 10 relative to the absolute surface resistivity.

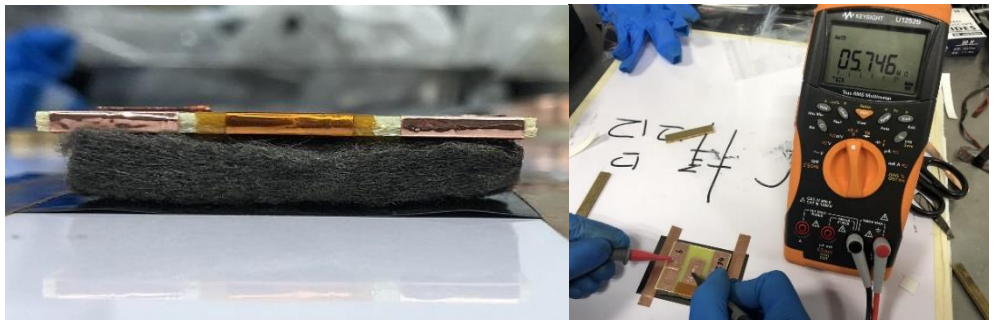
- Deposition parameters for 25cm × 25cm DLC sample:

  Deposition time: 30 min
  Target current: 2.8 A
  Initial vacuum degree: 1.4×10^{-5} Torr
  Bias voltage: 30V
  Thickness: ~210 nm

- The typical resistivity uniformity:

  23% (sigma/mean) @25cm×25cm

The height of the carbon target is about 30cm almost the same as our sample size. It results a larger surface resistivity at the edge of the target and lower at the central area.



Tool for surface resistivity measurement

25cm × 25cm DLC sample (Sigma/mean=23%)

32	32	32
19	18	17
27	26	27

Surface resistivity (MΩ/□)

Resistivity & thickness

- Surface resistivity is sensitive to the hydrogen, it can be adjusted in wide range by changing the gas flow of iC_4H_{10} .
- It can be adjusted more precise by controlling deposition time (DLC thickness ∝ deposition time).

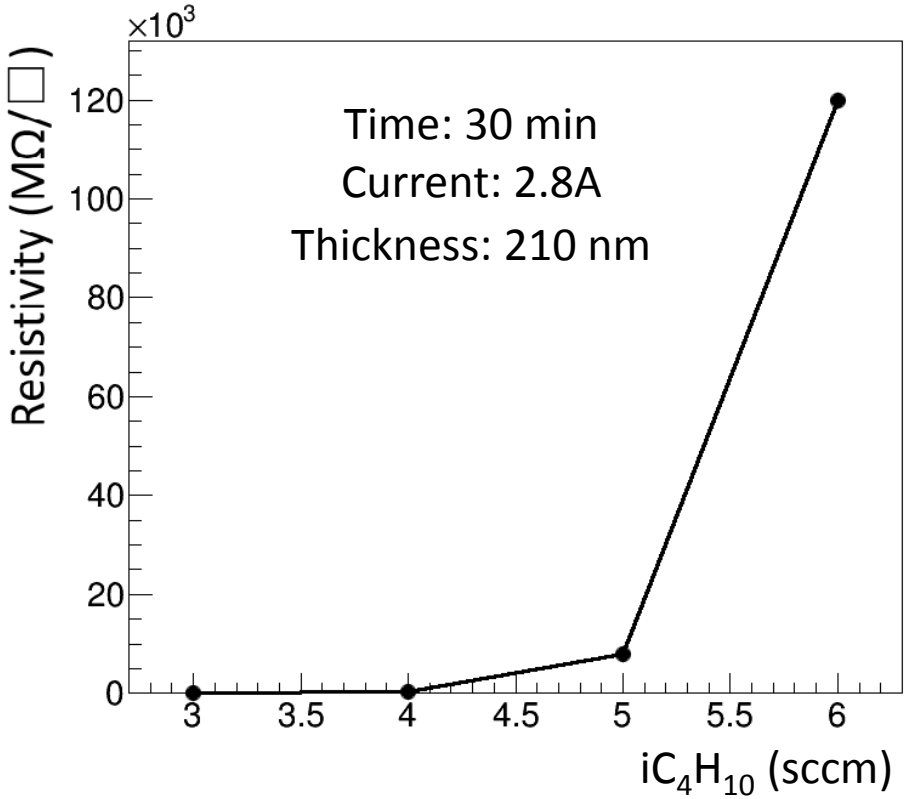
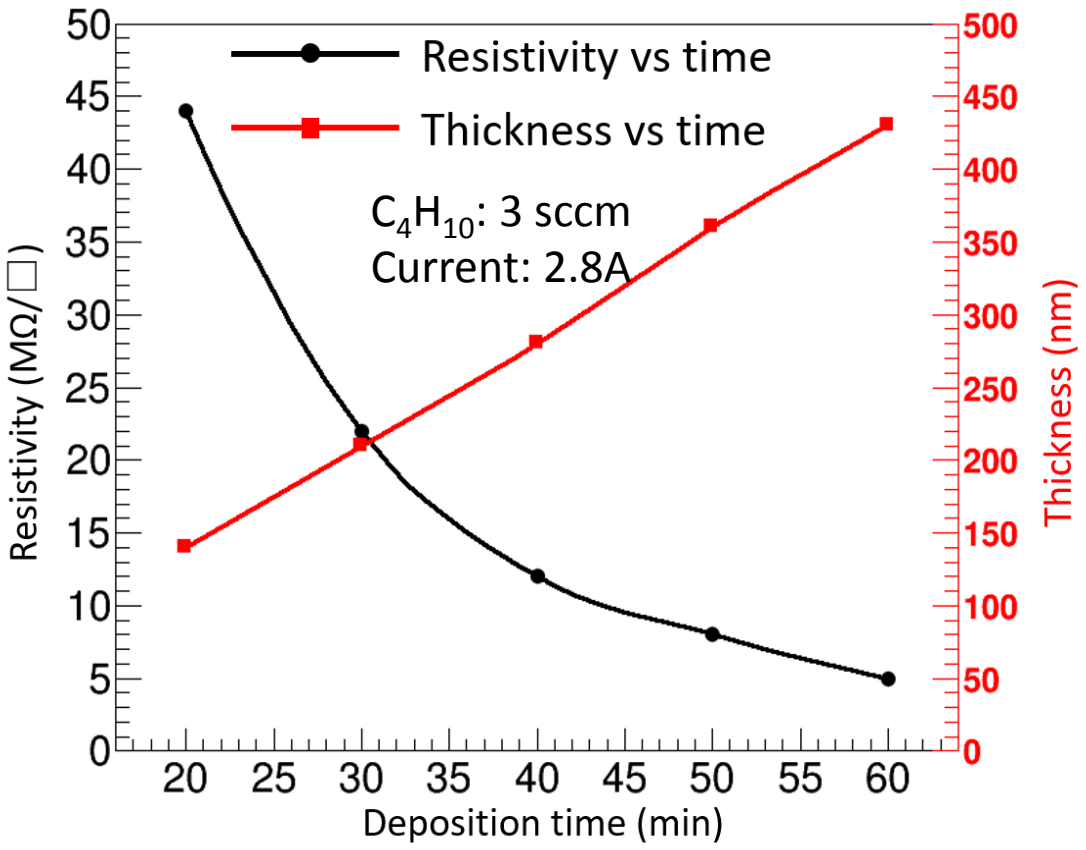
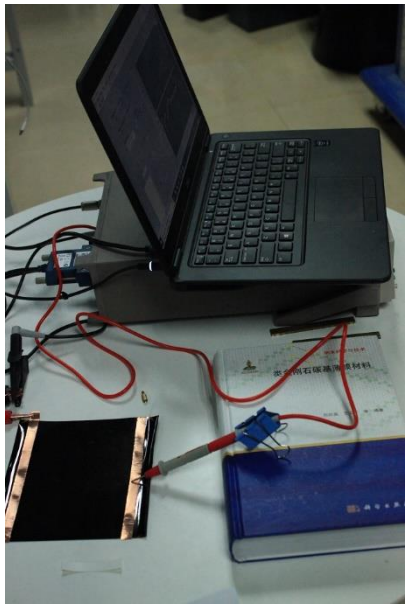


Fig. 3. Resistivity vs iC_4H_{10} gas flow

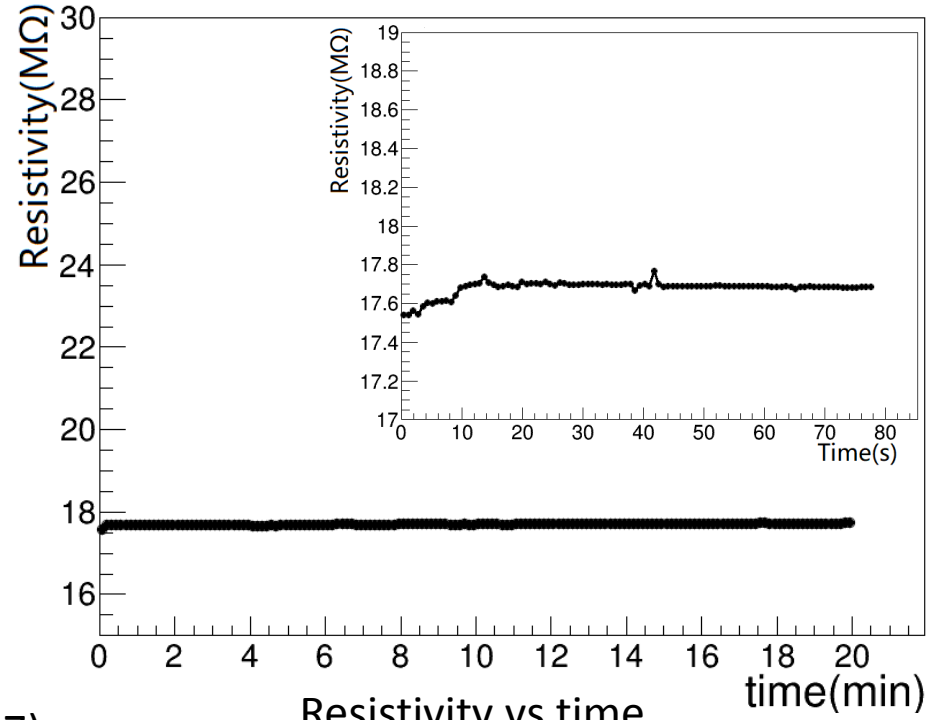


Resistivity vs voltage

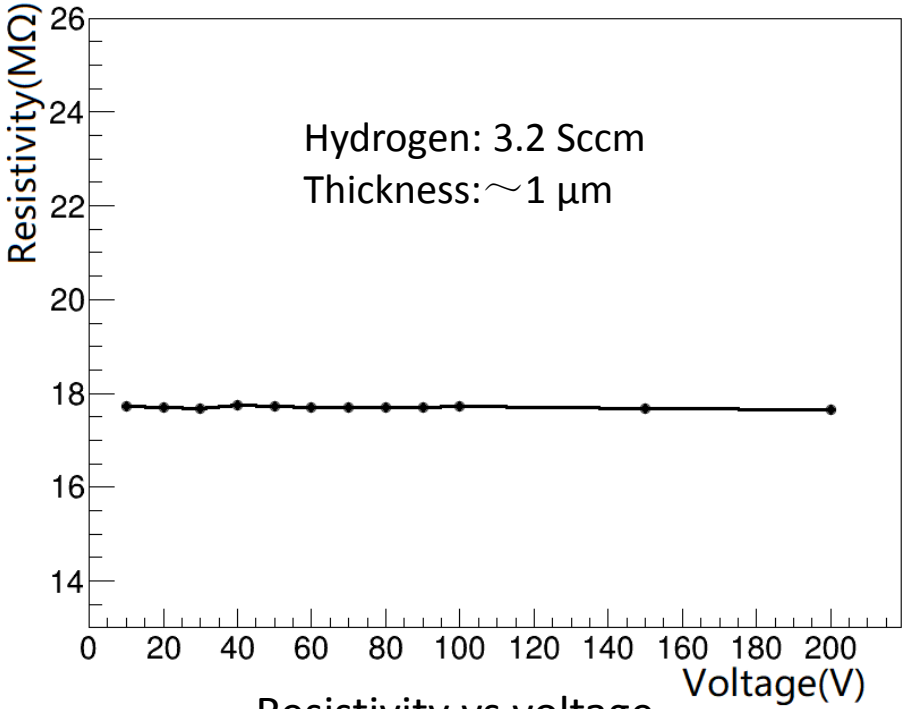
- Dependence test of resistivity with voltage applied on the DLC sample.
- The resistivity became stable immediately(～10s).
- Resistivity is independent with the voltage, showing the ohmic behavior.



Test system (Keithley 6487)



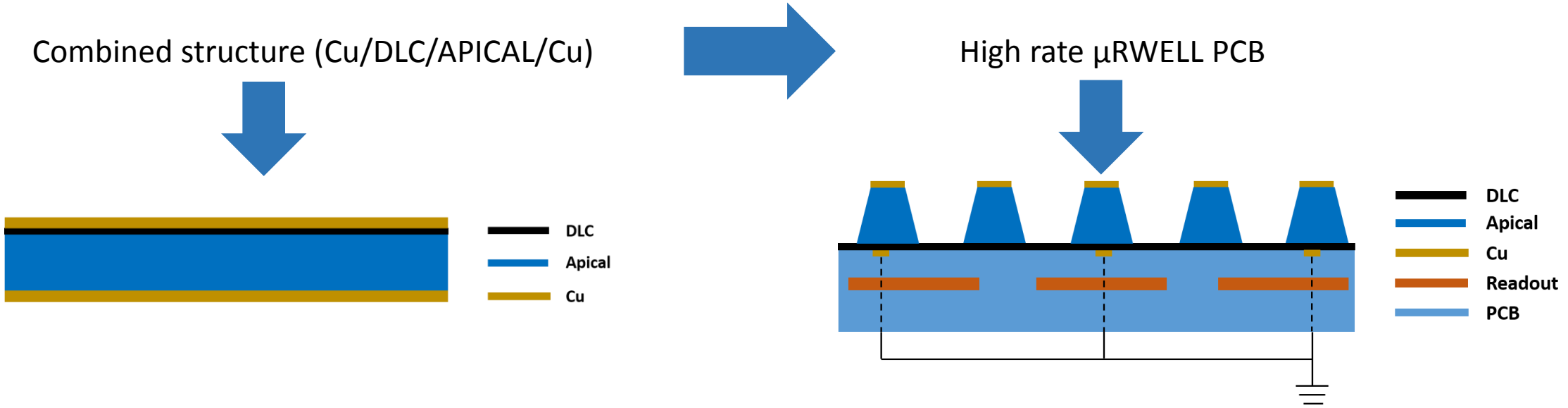
Resistivity vs time



Resistivity vs voltage

New combined structure (Cu/DLC/APICAL/Cu)

New combined structure (Cu/DLC/APICAL/Cu) is required to make high-rate µRWELL PCB.



- The copper clad on the DLC is etched to dash strips and grounded at every a few mm.
- The charges collected on the DLC can be quickly released via the grounded copper strips.

Technique of depositing copper on DLC needs to be developed.

This work was supported by a RD51 common project: DLC based electrodes for future resistive MPGDs.

Copper coating on DLC

Coating procedures:

1. Coat Chrome (~50nm) on DLC
2. 1 min “Chrome + Cu” coating
3. 300 min Cu coating

Structure of APICAL substrate

Before copper deposition (left). After copper deposition (right).

The temperature in the chamber after 300min copper deposition is 188 centigrade.

The surface resistivity would change after deposition of the copper due to the high temperature.
More detail about the change of resistivity with the temperature will be studied.

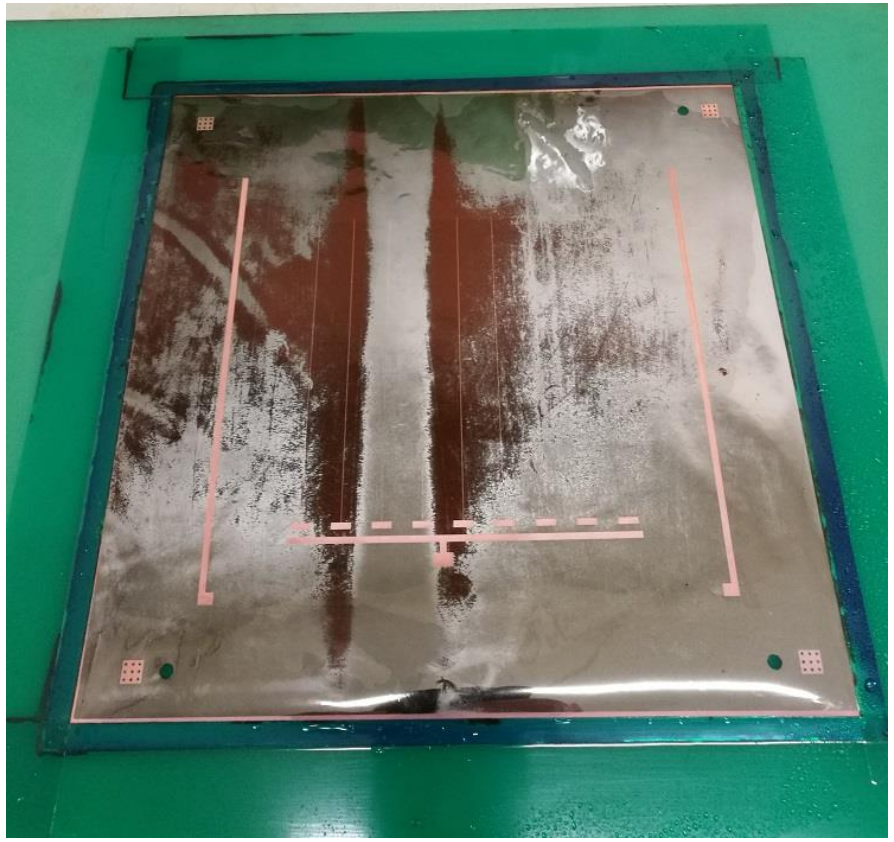
Problem of copper deposition

Problem of the current copper deposition DLC

- Chrome is too thick, need a very long etching time.
- “Chrome + Cu” co-deposition layer can not be etched.

Optimization of the copper deposition

- Adjust the thickness of chrome
- Adjust the thickness of “Chrome + Cu” co-deposition layer
- Change the transition layer (Titanium?)



Etching chromium of the µRWELL PCB

THANKS