# Preparation and Resistivity Measurement of the Nitrogen Doped DLC(a-C:N)

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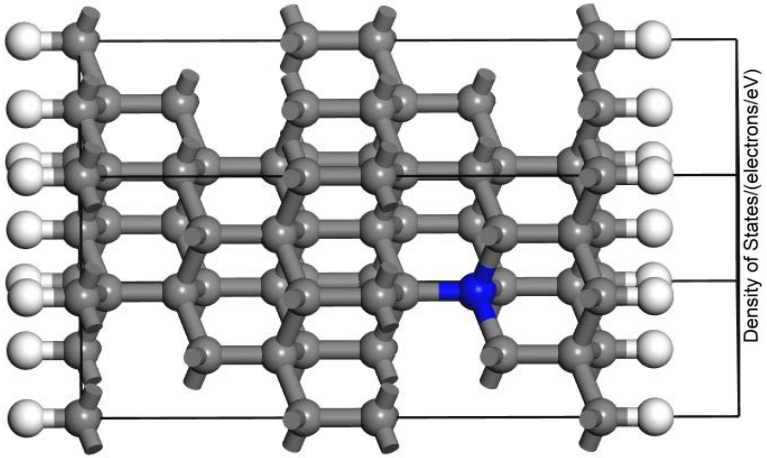
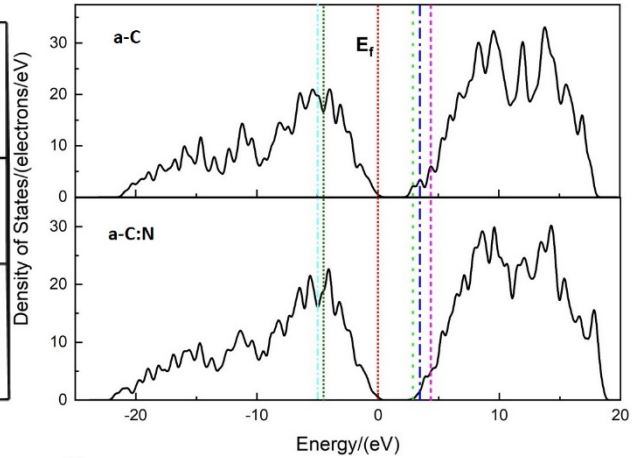
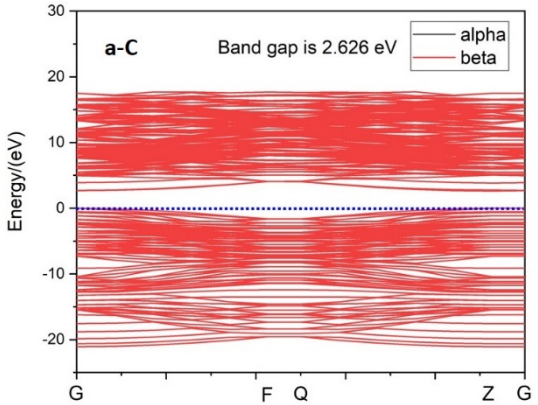
# The goal of the a-C:N preparation

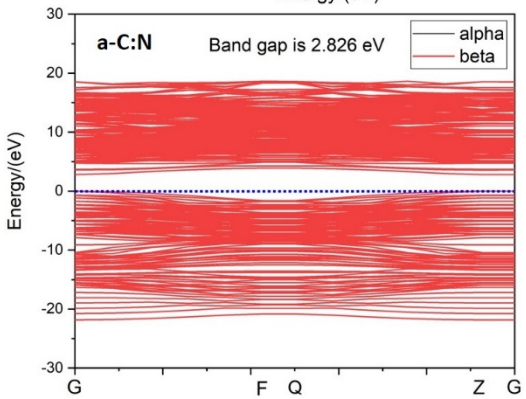
- We are trying to modeling the DLC, and have simulated the a-C:N, we want to compare the simulation results with the experimental results;

**Diamond (1,1,1) model**

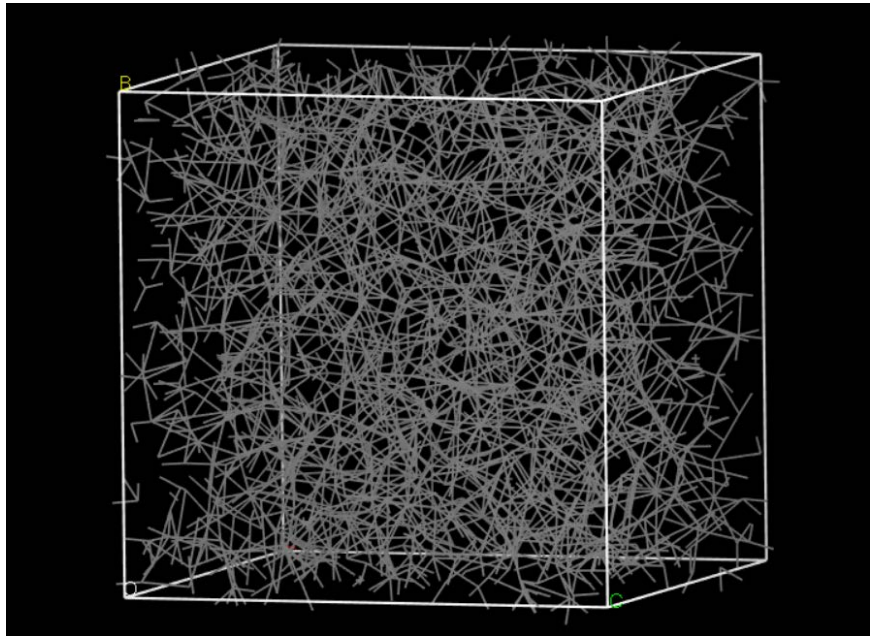





**DLC model**



**The diamond(1,1,1) model seems not suitable, we need build real DLC model in future !**

# Calibration for new target and baked materials

- High-purity graphite targets used(99.99%→99.999%), the sputtering power is higher than before;

| Sample | size | Vacuum | Time | Resistivity1 | Resistivity2 |
|---|---|---|---|---|---|
| 1 | 5cm×10cm | $1.2\times10^{-5}$Torr | 40min | 19MΩ/□ | * |
| 2 | 5cm×10cm | $1.2\times10^{-5}$Torr | 30min | 85MΩ/□ | * |
| 3 | 5cm×10cm | $1.2\times10^{-5}$Torr | 25min | 145MΩ/□ | * |
| 4 | 20cm×20cm | $1.6\times10^{-5}$Torr | 25min | 280MΩ/□ | 90MΩ/□ |
| 5 | 20cm×20cm | $1.4\times10^{-5}$Torr | 25min | 180MΩ/□ | 70MΩ/□ |

Resistivity1

Resistivity2

- Bake effects (150℃) of the raw materials

| Sample | Size | Resistivity | Bake |
|---|---|---|---|
| 1 | 25cm×25cm | 50(MΩ/□) | > 2 days |
| 2 | 25cm×25cm | 390(MΩ/□) | No |
| 3 | 5cm×10cm | 60(MΩ/□) | > 2 days |
| 4 | 5cm×10cm | 80(MΩ/□) | No |

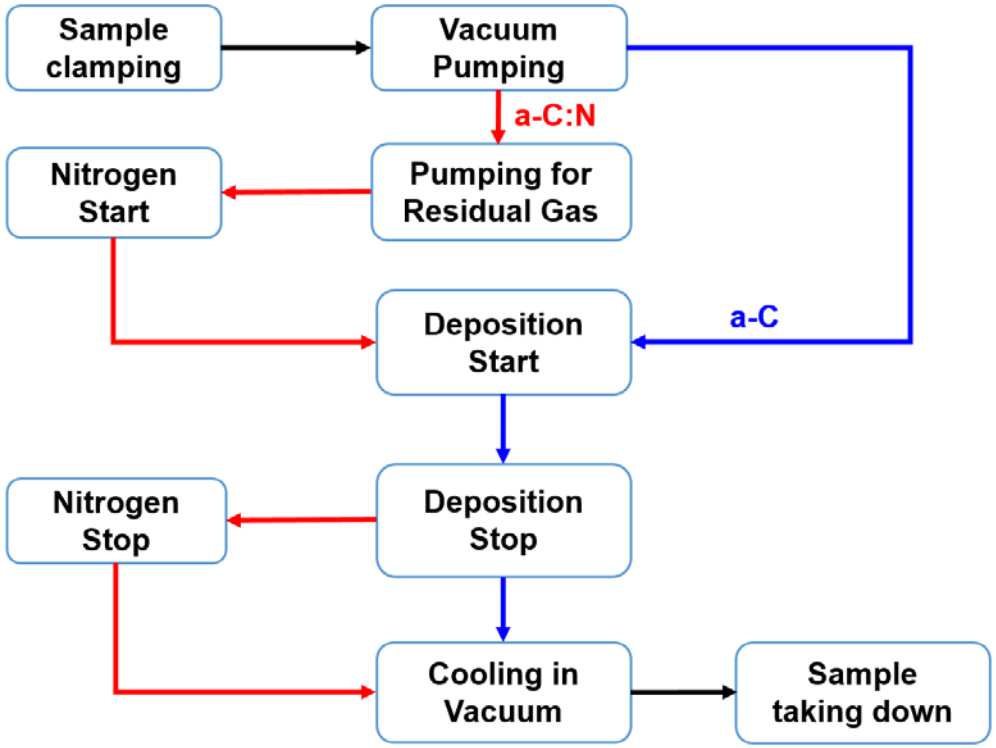
1. The large size (25cm×25cm) samples show that the resistivity of the no bake one is 8 times larger than that of the baked one

2. The small size (5cm×10cm) samples didn't show any significant difference

**We will do more systematic testing later!**

# Nitrogen Doped DLC(a-C:N) Deposition

## Replace the isobutane gas line to $N_2$



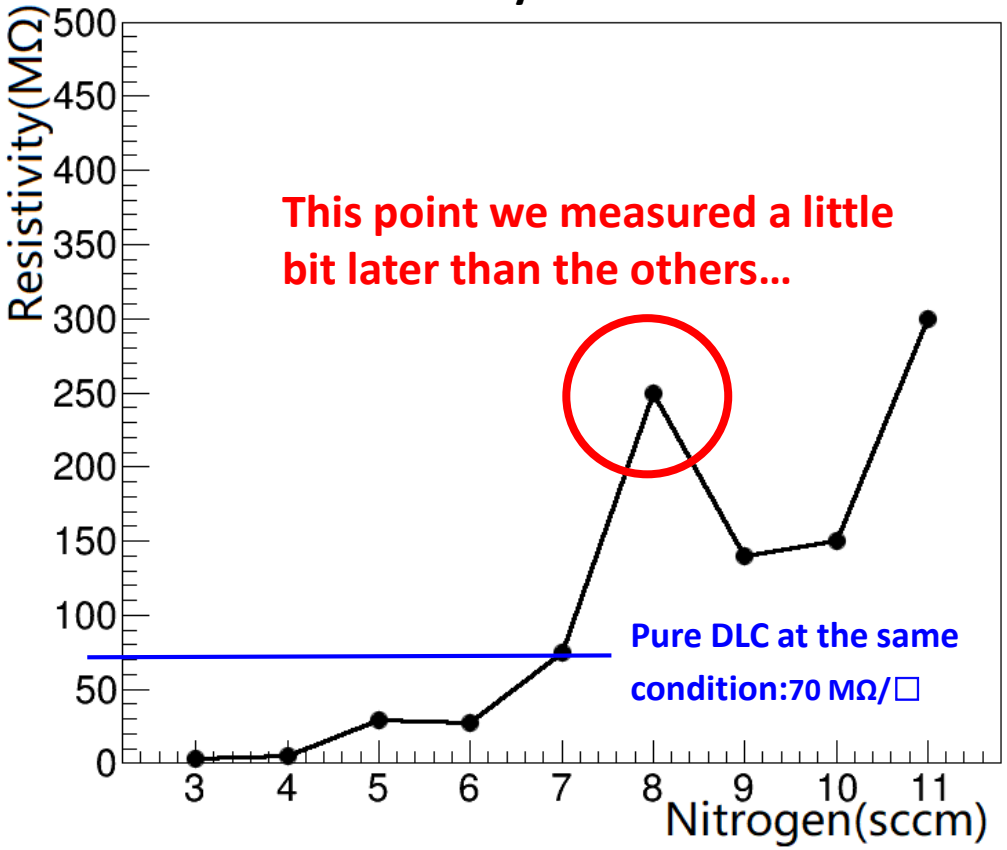

**Other important conditions:**

Target current: 1A

Deposition time: 25min

Vacuum degree: $1.4\times10^{-5}$ Torr

## Resistivity of the a-C:N




- The a-C:N is quite unstable, the resistivity increased 2～3 times during several minutes after it taken out from the sputtering chamber
- Lower nitrogen(<7sccm) a-C:N has lower resistivity than the pure DLC, while higher(>7sccm) ones has higher resistivity.

# “Vacuum” Storage test

1. A pure DLC sample was sealed in a “vacuum” bag immediately after it was taken out from the sputtering chamber
   - The resistivity of a-C:N changes too quick, so we chose the pure DLC, whose resistivity should slowly increase about 30% in 3 days, the resistivity has been measured before it was sealed in “vacuum” (0.01Mpa) bag;
   - Another sample came from the same batch was exposed in the air for 3 days, the initial resistivity is almost the same as the sealed one;

   We measured again after 3 days, the resistivities of two samples are more or less the same…

2. 2 batches of a-C:N (5sccm) samples are prepared, to see if the resistivity will change or not if they don’t touch the air
   - The 1st batch was taken out from the sputtering chamber immediately after the coating process finished, and we measured the resistivity immediately after they were take out from the vacuum;
   - The 2nd batch was stored in the sputtering chamber for 2 hours after the coating process finished, then we took them out and measured the resistivity immediately;

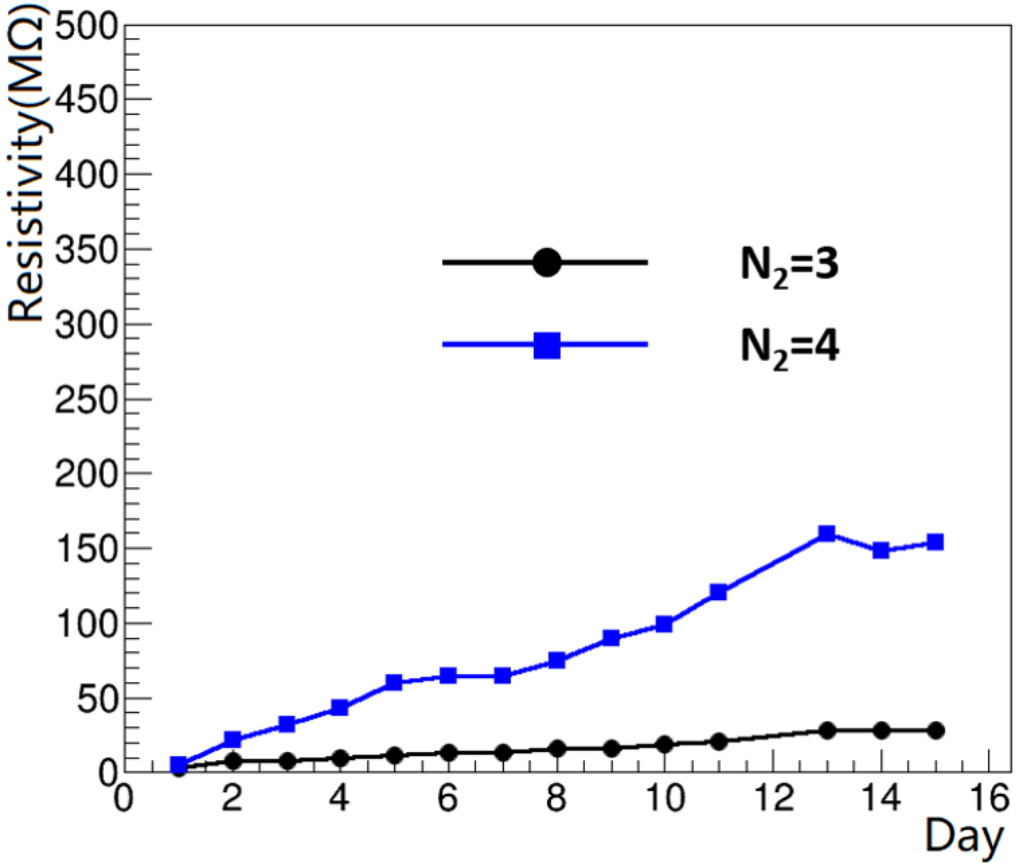
   The resistivity of the 2 batches of a-C:N we measured are more or less the same…

For sure that touching the air will trigger something out, we need more test to find the real reason, and try to modeling this effect to predict the change of the resistivity;

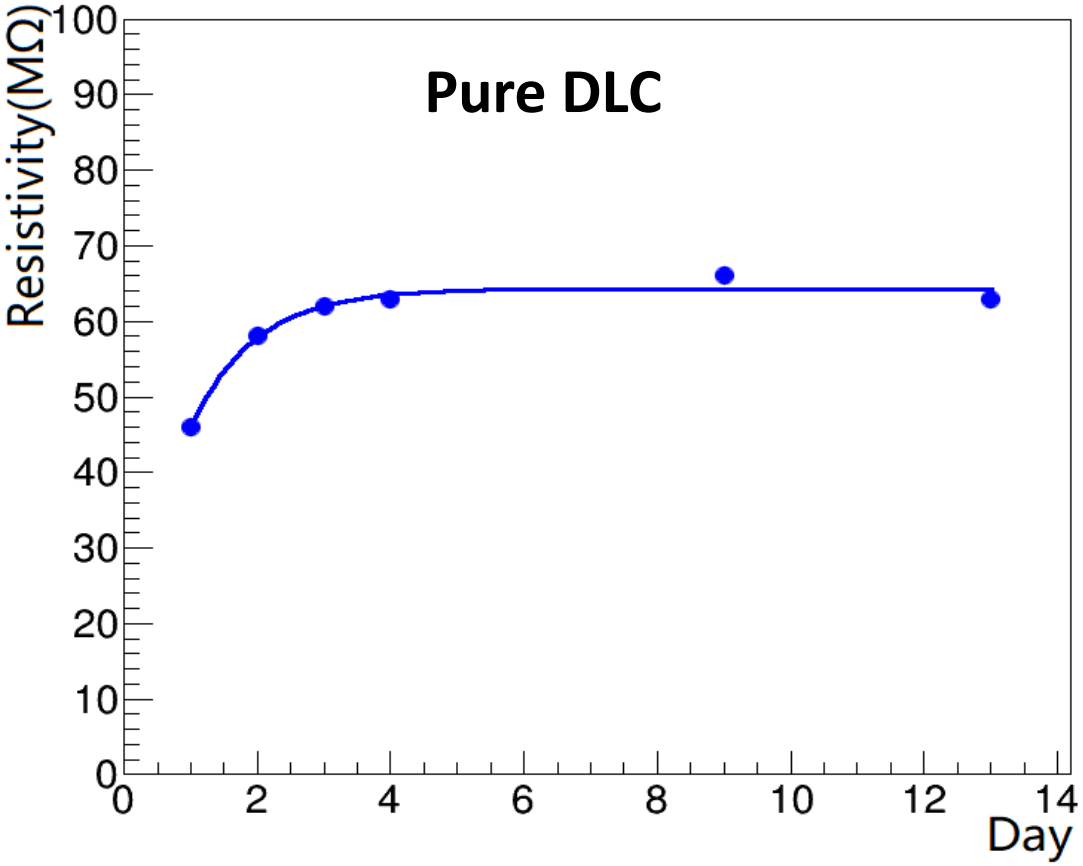
# Long time stability in air

**Measured by the multi-meter**

The resistivity of the a-C:N is still increasing after 15 days, no tendency to saturate

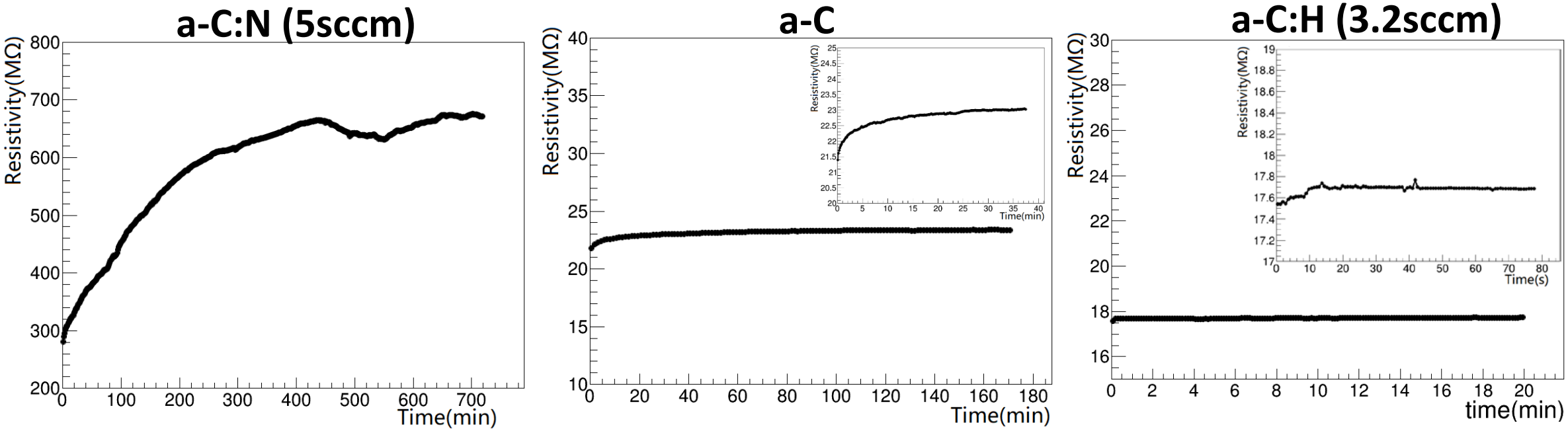



The resistivity of the a-C increased about 30% in three days, then became stable.




- The resistivity of the a-C/a-C:H is still stable after more than half an year

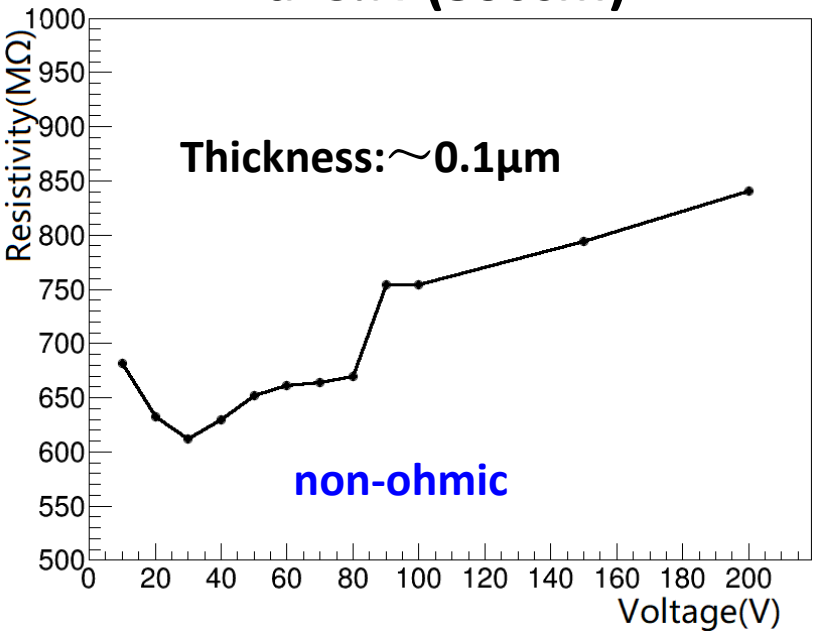
# Resistivity .VS. Time (Keithley6487,10V)

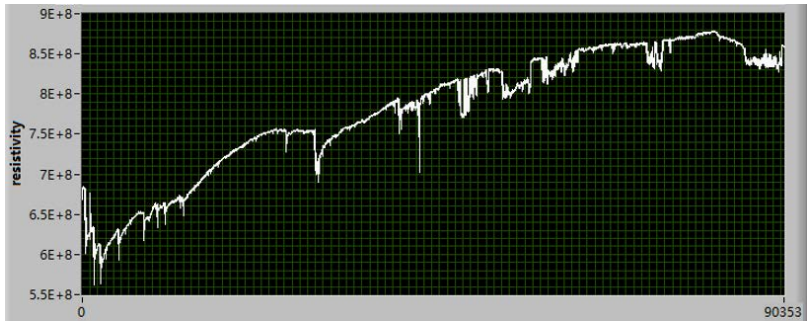



- The resistivity of the a-C:N (5sccm) increased more than 2 times after about 700min, then tended to saturate;
- The resistivity of a-C， increased about 7% during 30min and then goes into the plateau;
- The resistivity of a-C:H (3.2sccm)became stable immediately(～10s) after the voltage applied;

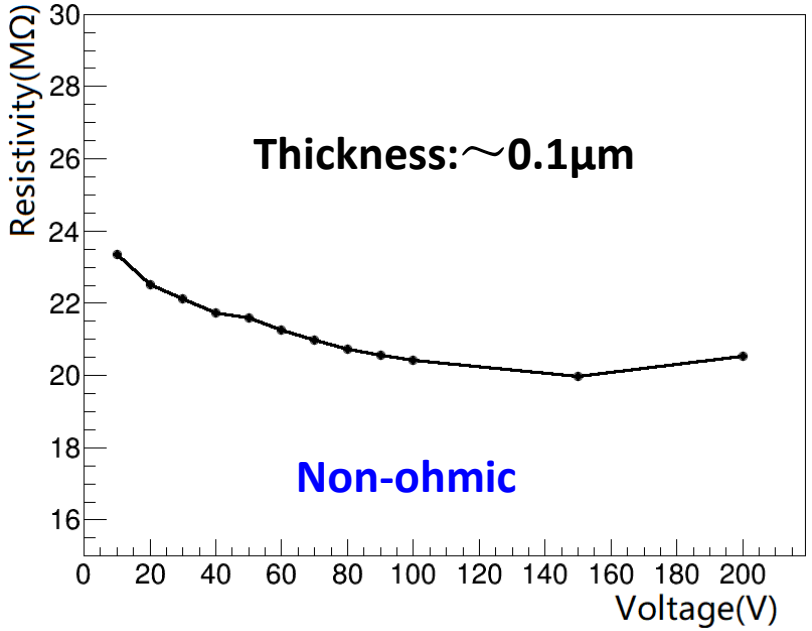
# Resistivity .VS. Voltage (Keithley6487)

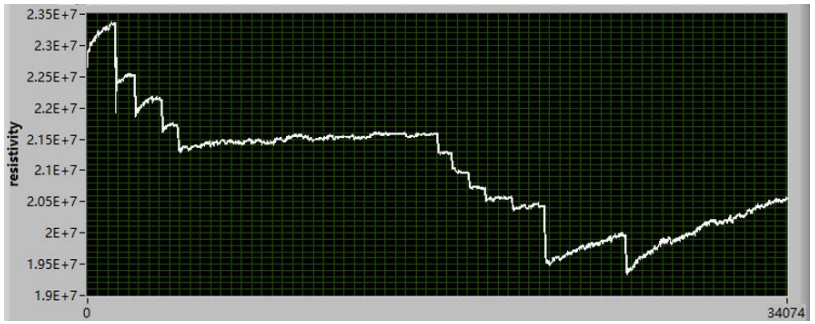
## a-C:N (5sccm)



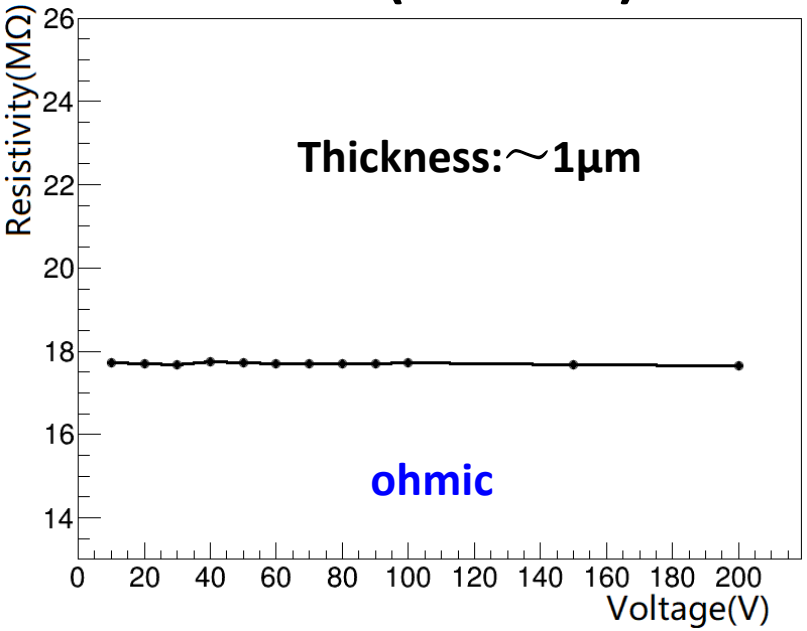



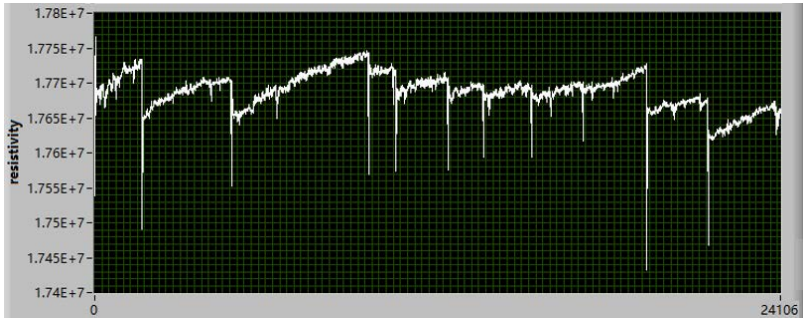

## a-C



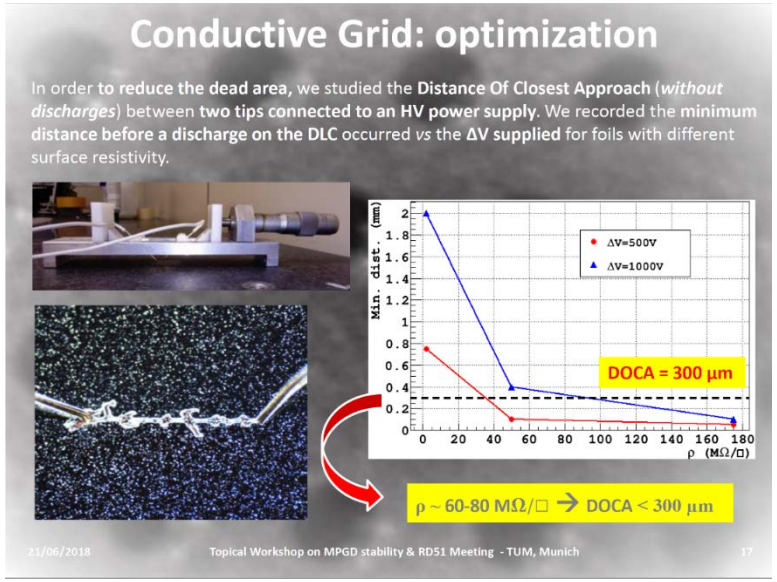

## a-C:H (3.2sccm)



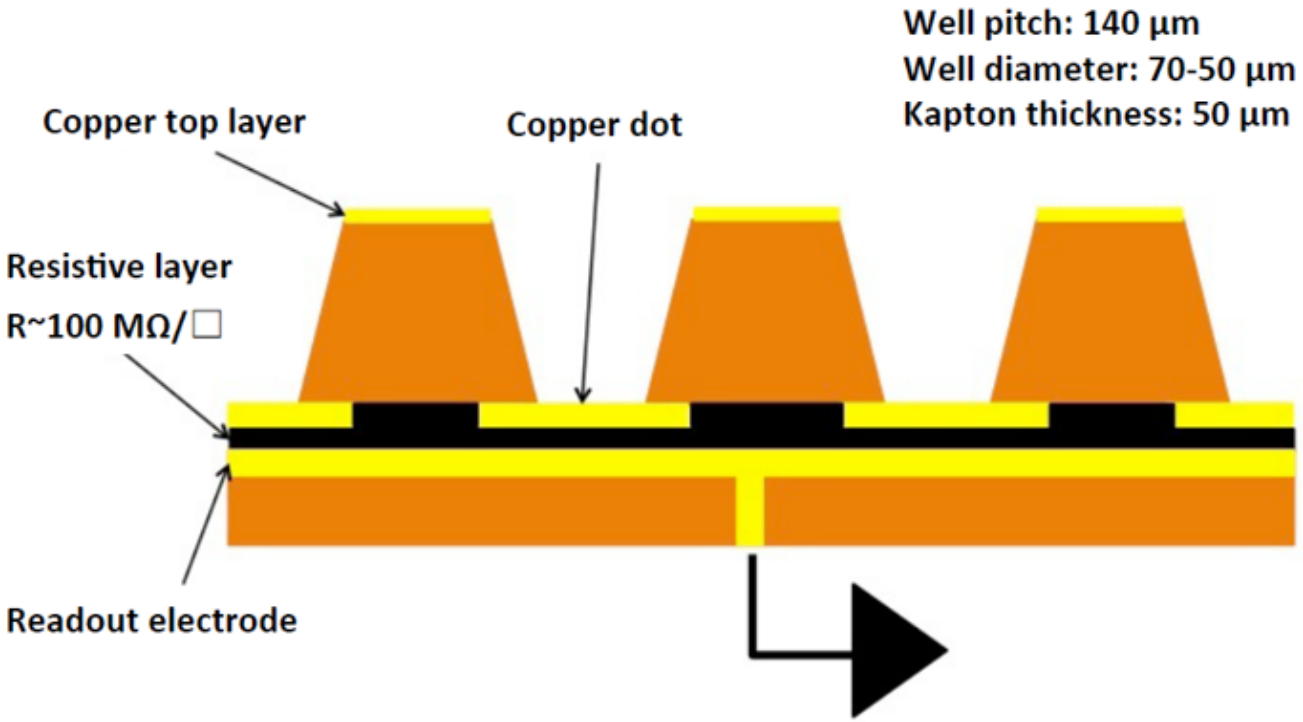




- **Only the a-C:H has the ohmic behavior, we have to find out if it caused by the thickness or the Hydrogen doped!**

# Near future work plan




| HR Layout | Resistive layer | Grounding pitch (grid/vias) | Grounding type | Dead-zone | Grid width | DOCA |
|---|---|---|---|---|---|---|
| SG2++ | single | 12 mm | Conductive grid | 0,3 + 0,3 mm | 100 um | 250 um |




- Continue the modeling and simulation of the DLC;
- To do more systematically test on the a-C:N;
- Scan the thickness, to check if the thick a-C will have good ohmic behaviors or not;
- Scan the thickness, to check if the thin a-C:H still have good ohmic behaviors or not;
- Try to make DLC foil(eg: a thick a-C:H foil) which has a DOCA less than 50µm under 1000V;