First Result of Charging-up “Free” THGEM Detectors

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Motivation

- Gas detectors with open insulator surfaces exhibit gain evolution versus time (charging-up effect). The evolution has been observed in LST, MSGC, GEM, THGEM....

- MSGC surface coating with DLC (Diamond-Like Carbon) was employed to overcome surface Charging-up and achieved good results in 1998.

- Coating DLC on THGEM dielectric surface may help to solve THGEM charging-up problem.

(a) Simulated electron avalanche in THGEM hole

(b) Measured gain stabilization over time at an X-ray rate of 100 Hz/mm², for an electrode with hole-rim (black) and without rim (blue)
Experimental setup

- Single-layer THGEM detectors were fabricated and tested.
- We measured anode current with pico-ammeter, irradiation rate with LTD and counter, charge spectrum with MCA.
- 95%Ar+5%Isobutane gas mixture.

(a) Cross section of the THGEM chamber

(b) Experiment flow diagram
Preliminary Results

- 200GΩ DLC-THGEM basic properties

(a) Fe55 5.9keV X-ray spectrum

FWHM 23%

(b) Gain versus HV

$E_D = 1.5\text{kV/cm}$

$E_{Ind} = 2\text{kV/cm}$

(c) Gain and energy resolution versus $E_{Drift}$

$\Delta V = 850\text{V}$

$E_{Ind} = 2\text{kV/cm}$

(d) Gain and energy resolution versus $E_{Induction}$

$\Delta V = 850\text{V}$

$E_D = 1.5\text{kV/cm}$

✓ Basic properties of DLC-THGEM are similar to normal THGEM
Preliminary Results

- **Gain of DLC-THGEM**

- DLC-THGEM achieved higher maximum gain compared with normal THGEM;
- DLC-THGEM achieved higher gain at lower voltage;
- To achieved same gain, DLC-THGEM with lower resistance needs lower voltage.
- DLC layer modified THGEM electric field. To understand this effect, calculations and simulations are needed.
Time evolution of Gain

- 1TΩ DLC-THGEM
  \( E_D = 1.5\text{kV/cm} \)
  \( E_{\text{ind}} = 2\text{kV/cm} \)
  \( \Delta V_{THGEM} = 810\text{V} \)

- \( Fe55 \) source\(~70Hz/mm^2\)

✓ No significant anode current decrease or rise observed in 12 hours.
✓ Current variation smaller than 5%.
Time evolution of Gain

- 1TΩ DLC-THGEM
  \[ E_D = 1.5 \text{kV/cm}, \]
  \[ E_{Ind} = 2 \text{kV/cm} \]
  \[ \Delta V_{THGEM} = 810 \text{V} \]

- 8keV Xray~10kHz/mm²

✓ No significant anode current decrease or rise observed in 11 hours.
✓ Current variation smaller than 5%.
Time evolution of Gain

- 1TΩ DLC-THGEM
  $E_D=1.5\text{kV/cm}$,
  $E_{ind}=2\text{kV/cm}$
  $\Delta V_{THGEM} = 810\text{V}$

- 8keV X-ray~$400kHz/mm^2$

✓ Anode current increased by 12% in 12 hours at very high irradiation rate.
Time evolution of Gain

- Gain evolution of a series of DLC-THGEM and normal THGEM

A

B

- Short term charging-up Gain decrease less than 10%
- Long term charging-up removed.
Time evolution of Gain

- Gain evolution of DLC-THGEMs at different irradiation rates.

- Gain variation <5% when irradiation rate <100kHz/mm².

- DLC-THGEM with lower resistance shows smaller Gain variation.
Summary

- Single-layer DLC-THGEM detectors have been tested in different working conditions.
- DLC-THGEM shows good gain stability and no significant charging-up effect compared to the standard THGEM up to the rate 100kHz/mm².
- Lower resistance DLC-THGEM is able to achieve higher gain at even lower voltage compared to the standard THGEM.
- The gain of DLC-THGEM decreases quickly while the irradiation rate increases.
Future work

1. Other properties such as aging effects, gain uniformity, spatial resolution will be tested;

2. To understand how the DLC layer affects the detector physics, the MC study on THGEM will be performed;

3. Improving the rate capability, try resistive THGEM and fast grounding THGEM.
THANK YOU!