R&D on THGEM with Resistive Diamond-like Carbon Coating

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Outline

1. Motivation
2. Coating DLC on THGEM
3. DLC-THGEM Performance
4. Resistive THGEM
5. DLC RWELL
6. Summary

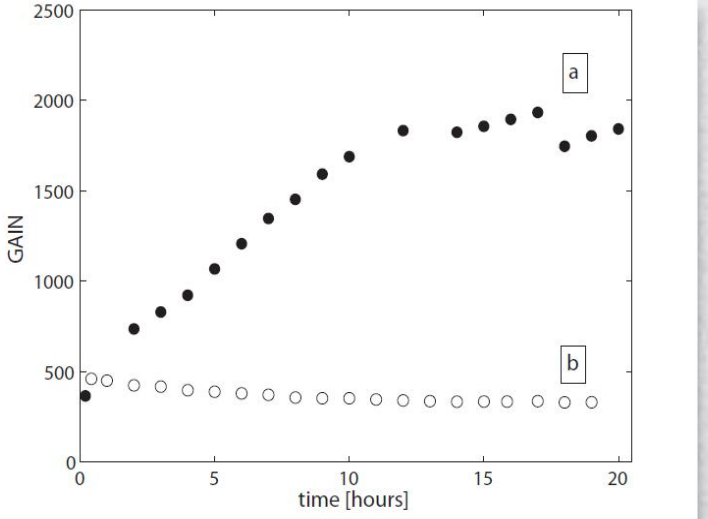
Motivation

THGEM Charging-up effect

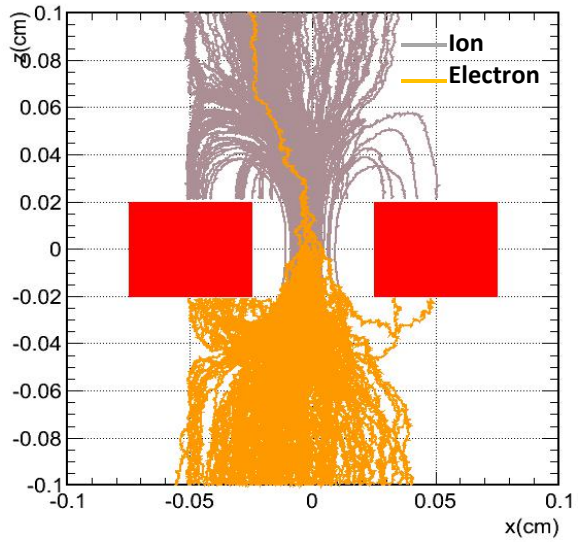
Electric charge accumulated on dielectric material of THGEM, causing time-dependent gain variation.

Possible solution

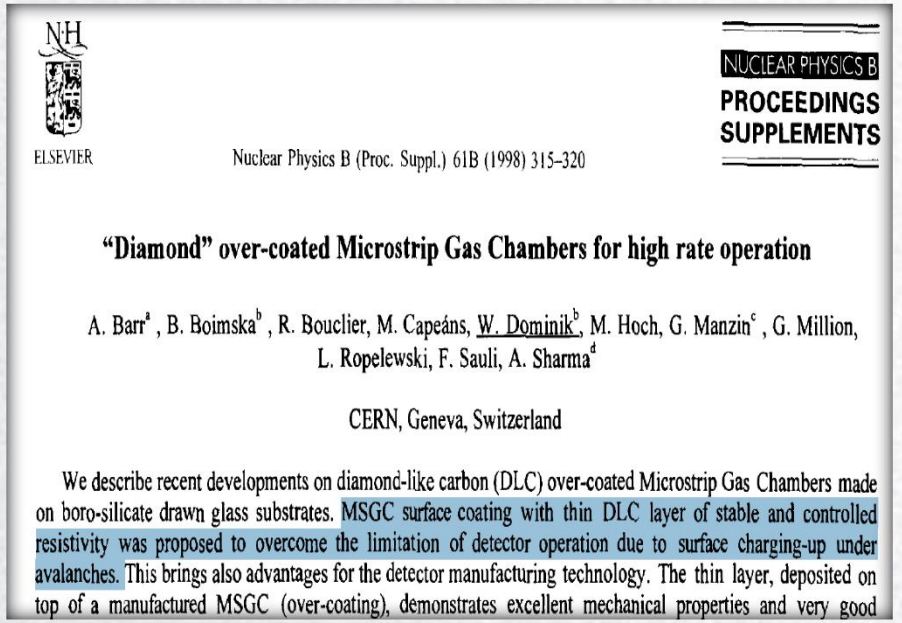
MSGC surface coating with DLC (Diamond-Like Carbon) was employed to overcome surface Charging-up in 1998. Coating DLC on THGEM may help evacuating charges.



Time-evolution of the gain of THGEMs



Simulated Electron avalanche in THGEM



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Nuclear Physics B (Proc. Suppl.) 61B (1998) 315–320

NUCLEAR PHYSICS B PROCEEDINGS SUPPLEMENTS

"Diamond" over-coated Microstrip Gas Chambers for high rate operation

A. Barr[a], B. Boimska[b], R. Bouclier, M. Capeáns, W. Dominik[b], M. Hoch, G. Manzin[c], G. Million, L. Ropelewski, F. Sauli, A. Sharma[d]

CERN, Geneva, Switzerland

We describe recent developments on diamond-like carbon (DLC) over-coated Microstrip Gas Chambers made on boro-silicate drawn glass substrates. MSGC surface coating with thin DLC layer of stable and controlled resistivity was proposed to overcome the limitation of detector operation due to surface charging-up under avalanches. This brings also advantages for the detector manufacturing technology. The thin layer, deposited on top of a manufactured MSGC (over-coating), demonstrates excellent mechanical properties and very good

*M. Alexeev et al 2015 JINST **10** P03026, The gain in Thick GEM multipliers and its time evolution*

Coating DLC on THGEM

Magnetron sputtering

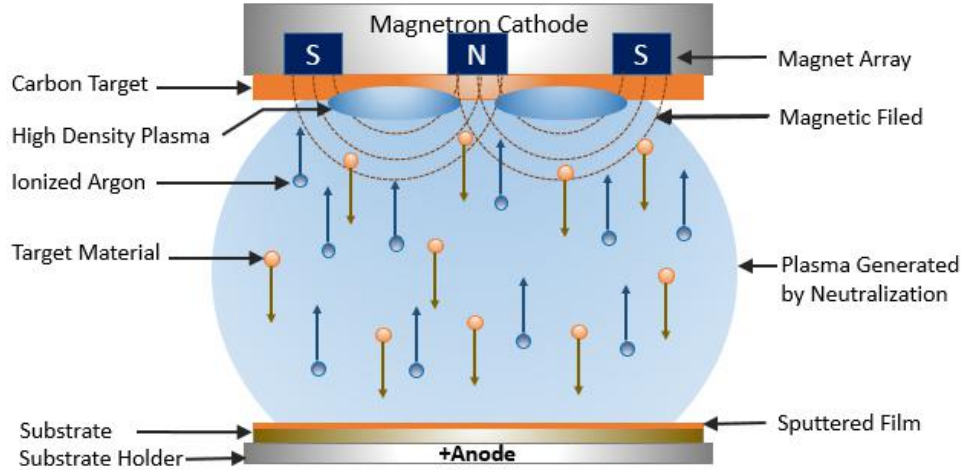
A Plasma Vapor Deposition (PVD) process, was used to produce DLC layer with controllable thickness and resistivity.

THGEM parameters

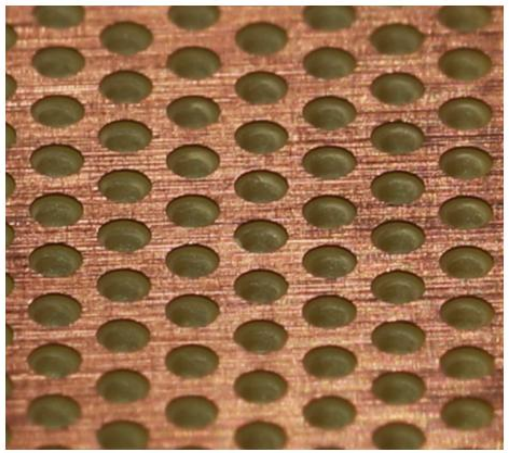
Sensitive area 5cm X 5cm, thickness 0.4mm, diameter 0.5mm, pitch 1mm, rim width 90μm.

DLC-THGEM

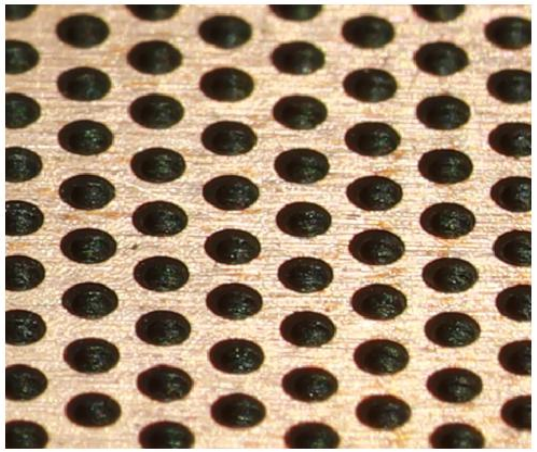
DLC layers of different resistivity were coated on a series of THGEMs (DLC-THGEM).
DLC thickness: 800nm. DLC resistance between THGEM copper electrodes: 68GΩ~6.7TΩ



magnetron sputtering



Photography of the bare THGEM



DLC-THGEM

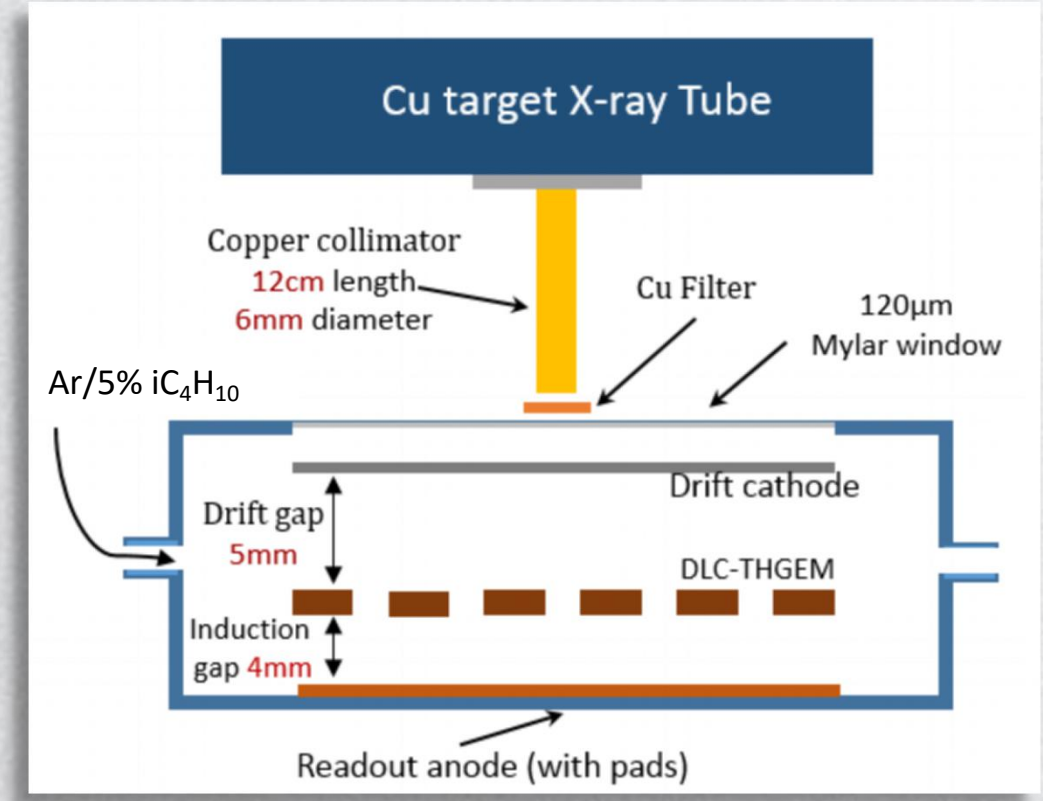
Experimental Setup

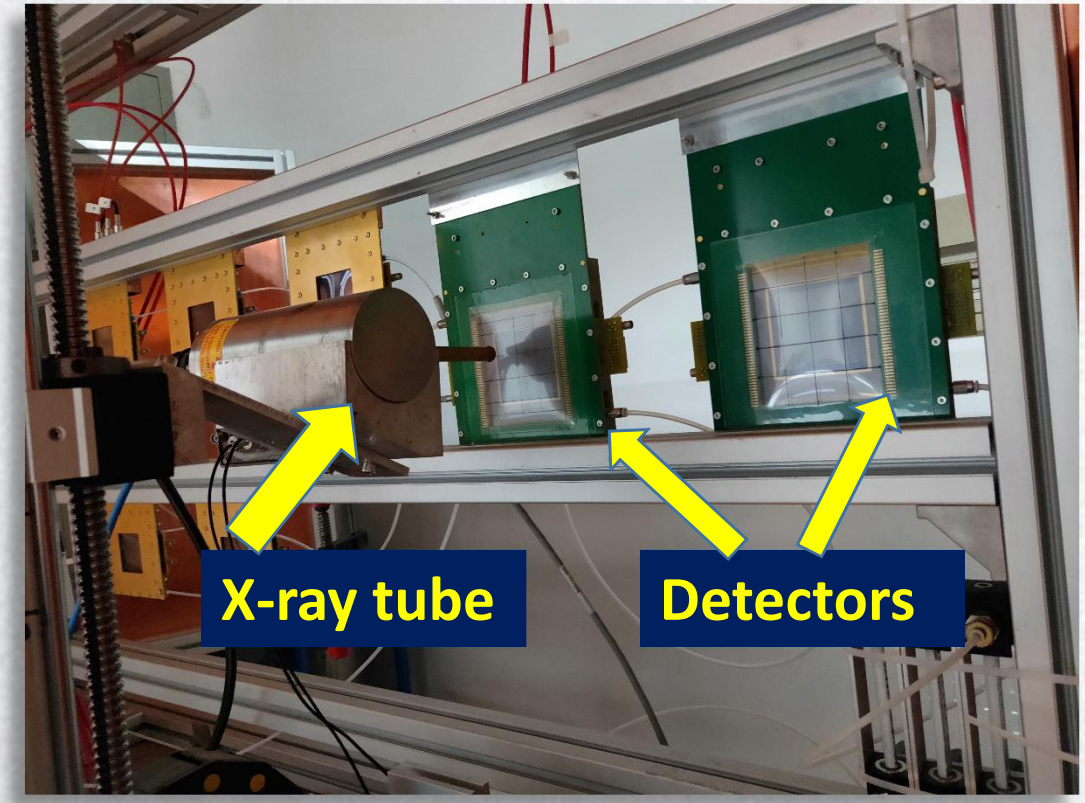
Detector structure

DLC-THGEM detectors, drift gap 5mm, induction gap 4mm.

Setup

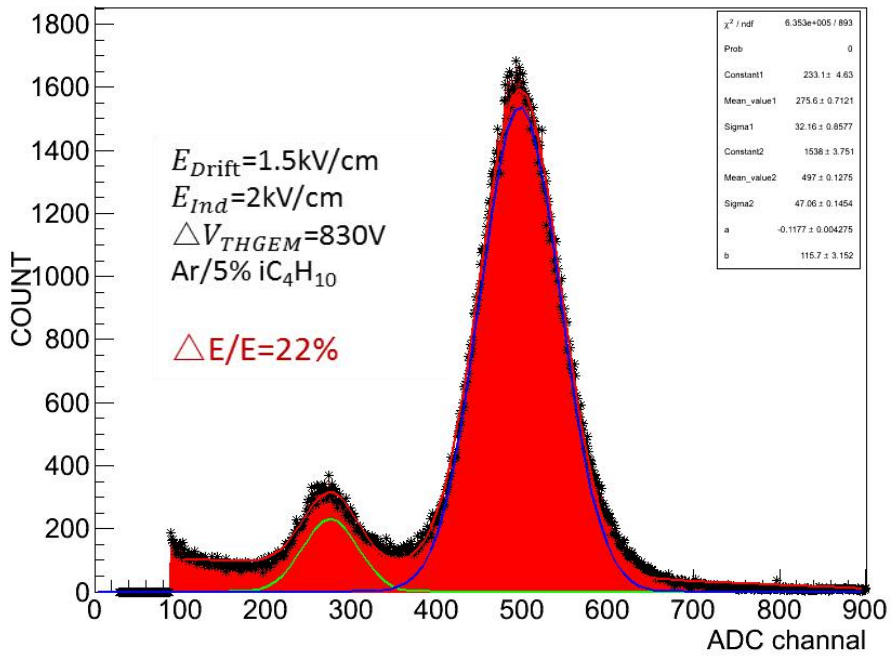
Detector chamber flushed with Ar/5% iC_4H_{10}. Cu target X-rays are collimated and filtered. Anode current was monitored with a picoammeter for gain monitoring. Fe55 X-ray also used in gain measurements.



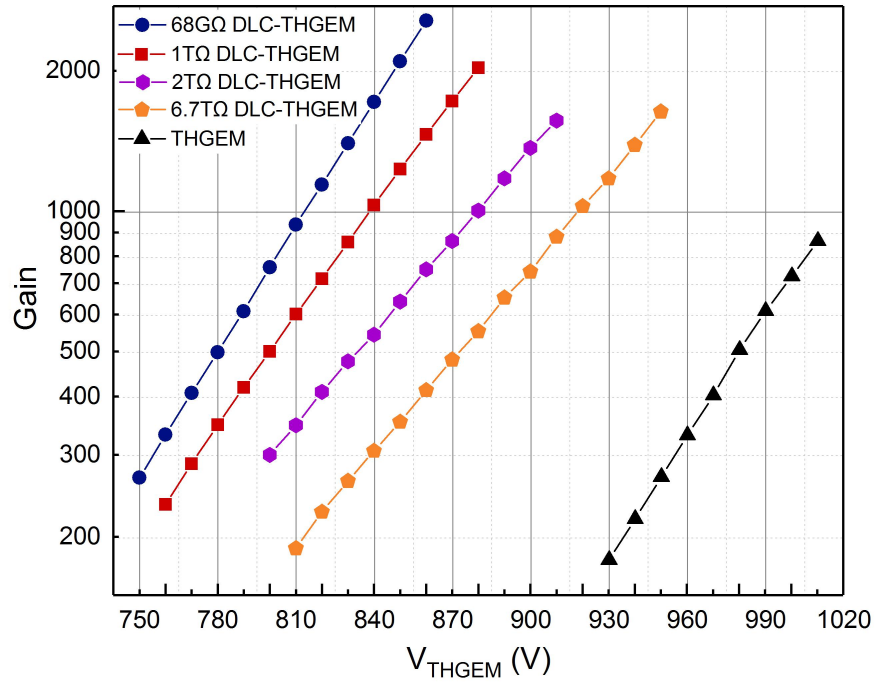


DLC-THGEM Performance

DLC-THGEM energy resolution and gain



1TΩ DLC-THGEM 5.9keV X-ray spectrum



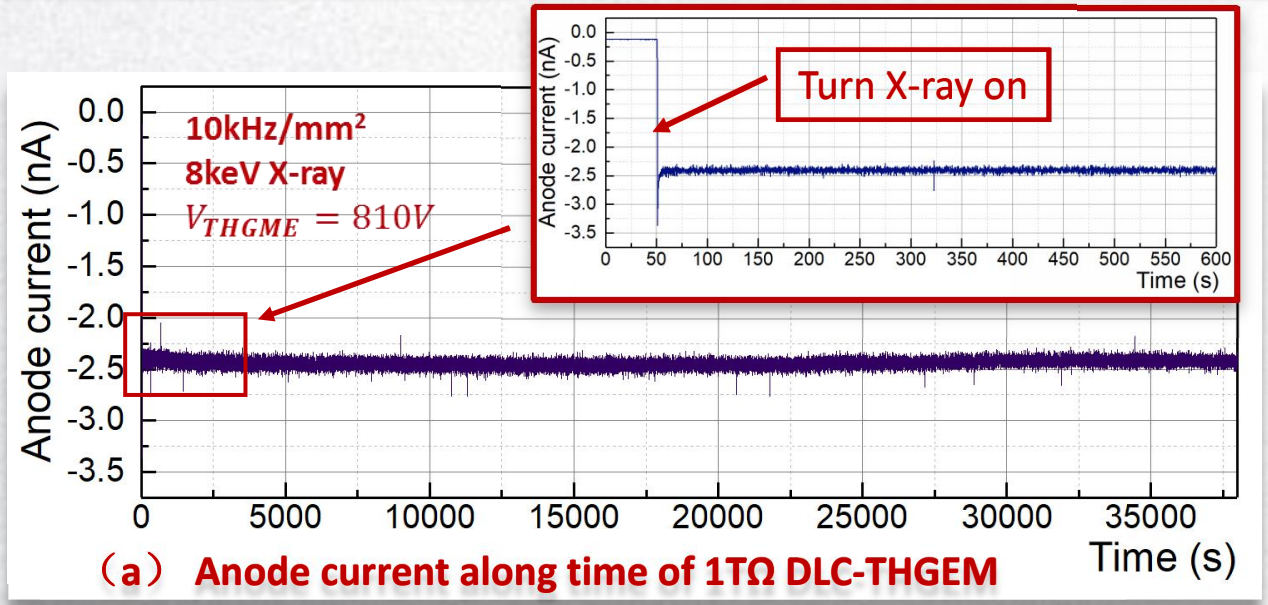
Gain curves of DLC-THGEMs with different resistance

- 22% Energy resolution to 5.9keV X-ray.
- DLC-THGEM achieved higher gain at lower voltage compared to normal THGEM.
- To achieved same gain, DLC-THGEM with lower resistance needs lower voltage.

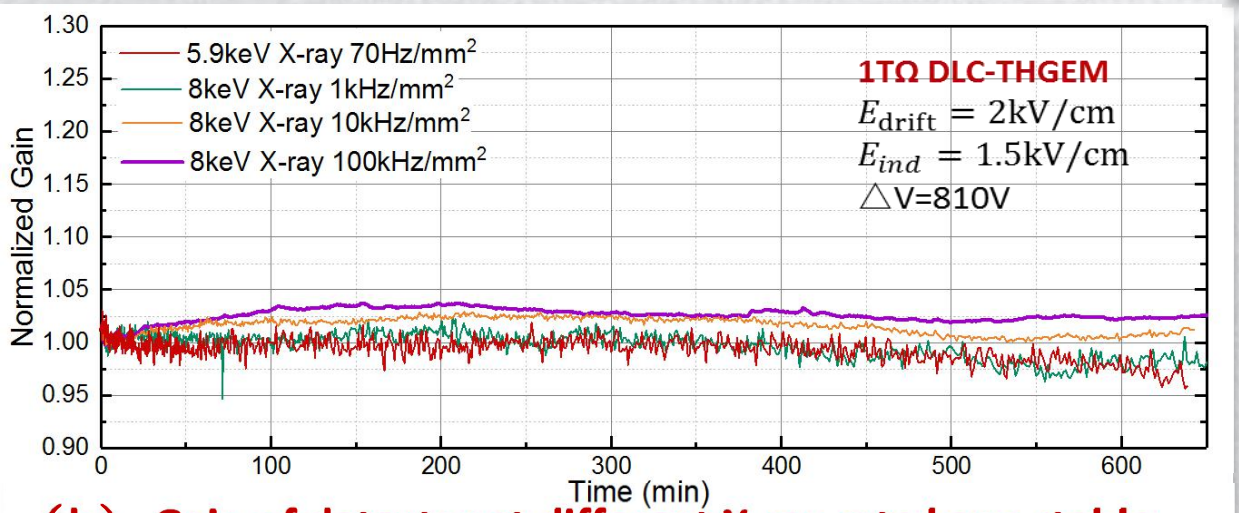
DLC-THGEM Gain Stability

Gain evolution along time

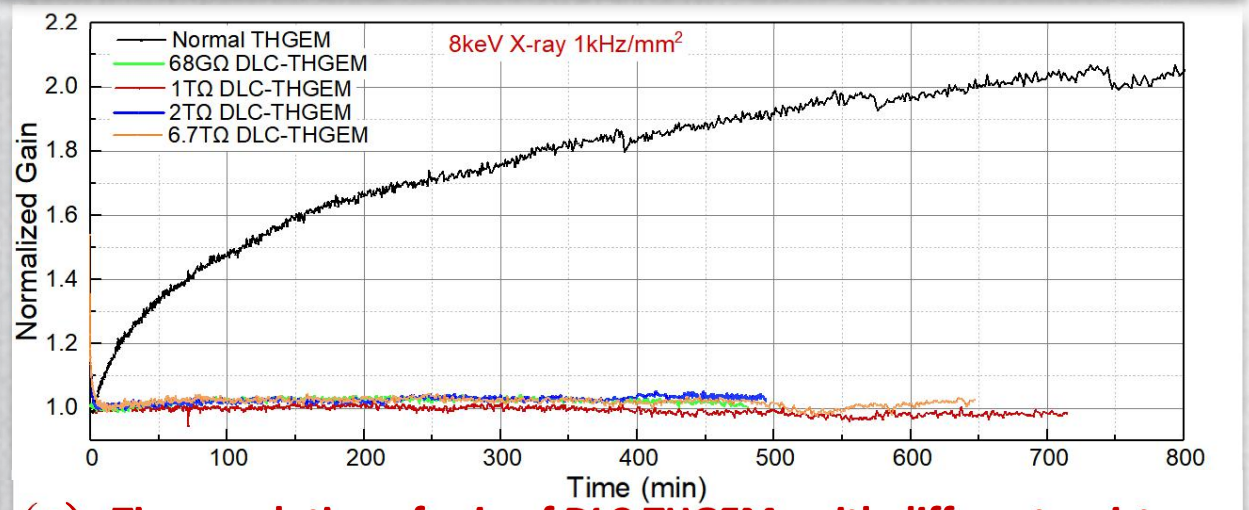
- When continuously irradiated with 8keV X-ray 6mm diameter beam, DLC-THGEM anode current is very stable
- Gain variation less than 5% irradiation rate up to 100kHz/mm^2 in 10 hours.
- ✓ No charging-up.



（a） Anode current along time of 1TΩ DLC-THGEM



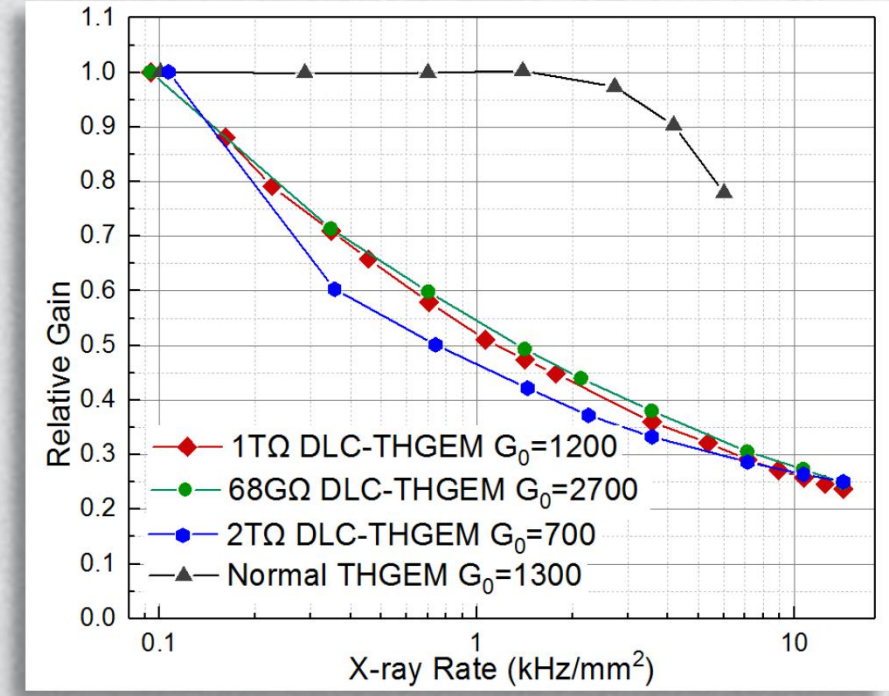
（b） Gain of detector at different X-ray rate keep stable.

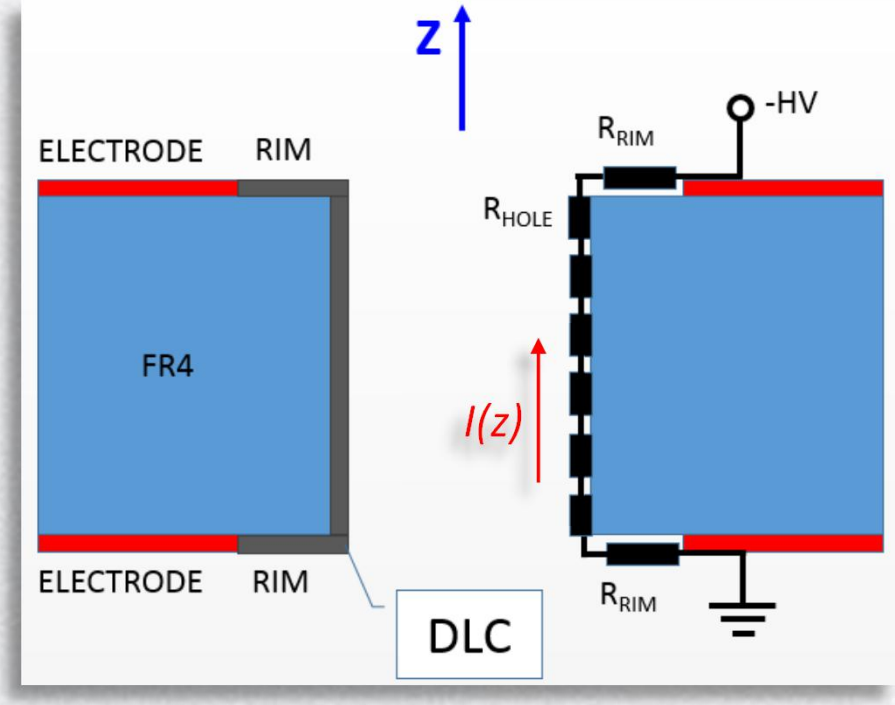


（c） Time evolution of gain of DLC-THGEMs with different resistance

DLC-THGEM Rate Capability

Gain at different X-ray irradiation rate



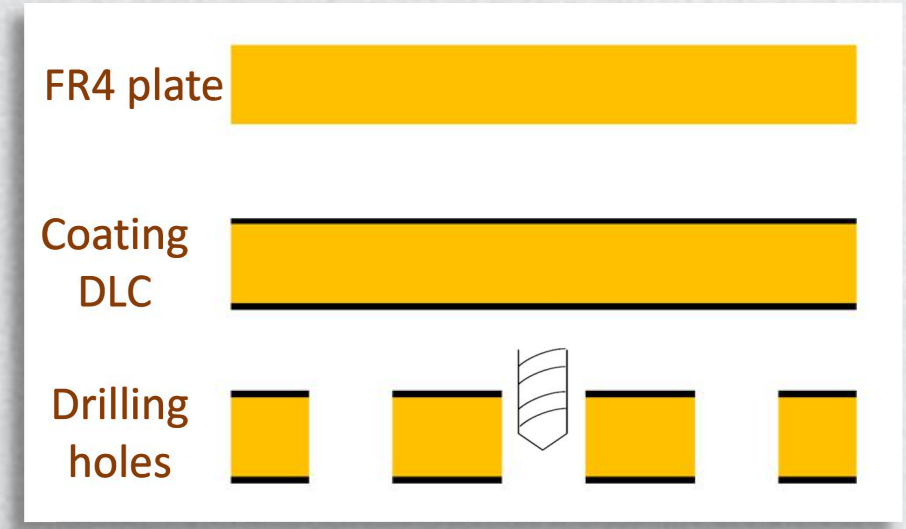


- DLC-THGEM gain decreasing along X-ray rate.
- The avalanche charges drifting onto DLC will contributed to the current and voltage bias on DLC, which is relevant to irradiation rate.
- Possible solution is Resistive THGEM without rim and no DLC in hole.

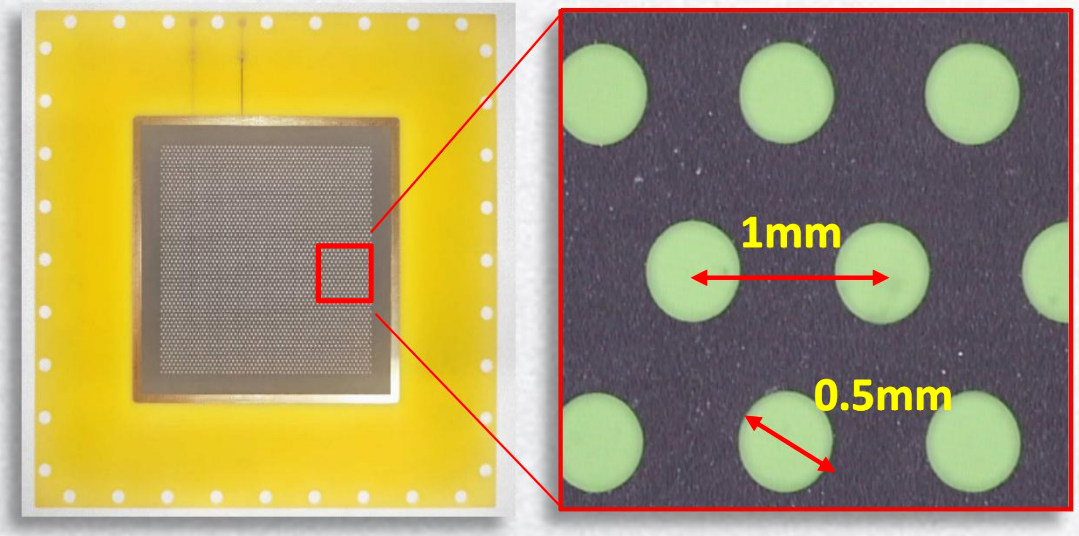
Resistive THGEM

Resistive THGEM with DLC electrodes

- Resistive THGEM (RTGEM) with DLC electrodes produced.



RTGEM production process

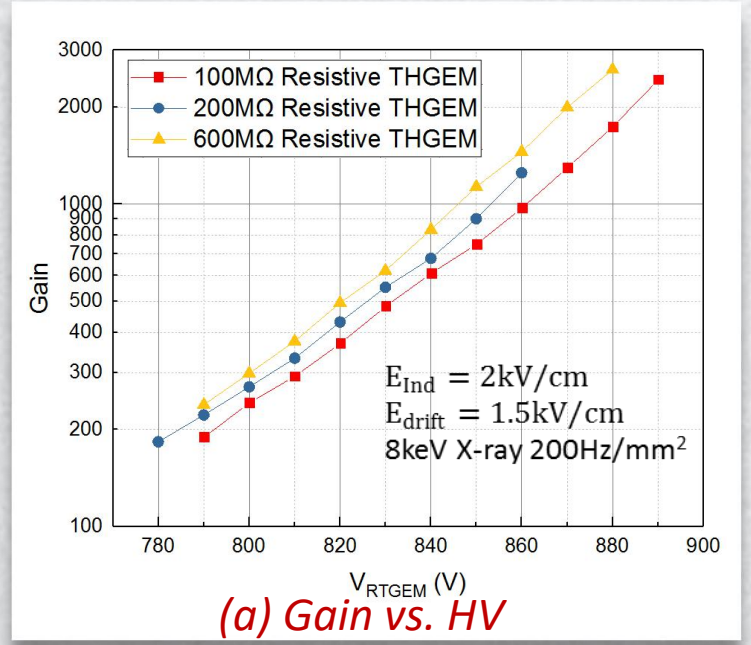


RTGEM

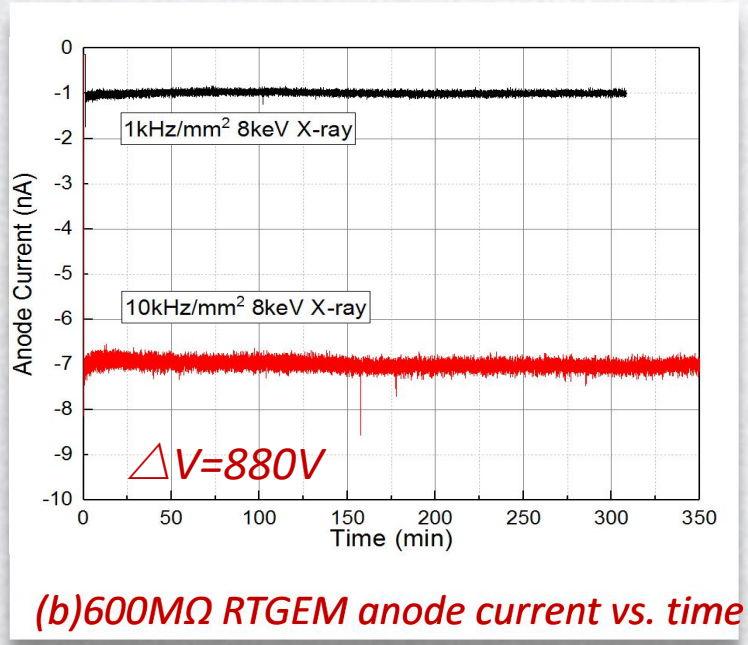
- Active area: 5cm X 5cm, thickness 0.4mm, diameter 0.5mm, pitch 1mm, no rim.
- DLC thickness 100nm~800nm, resistivity 100MΩ/□~1GΩ /□.

Resistive THGEM

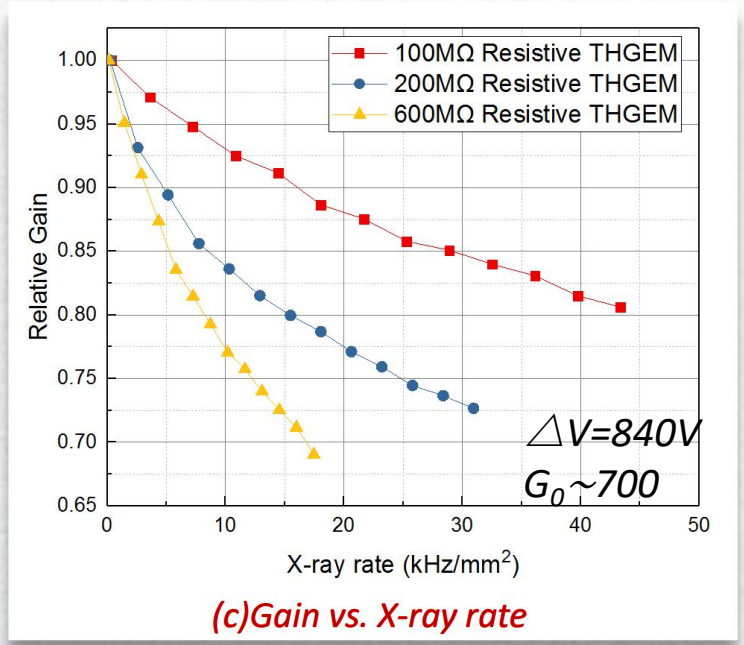
Gain performance of RTGEM



(a) Gain vs. HV



(b)600MΩ RTGEM anode current vs. time

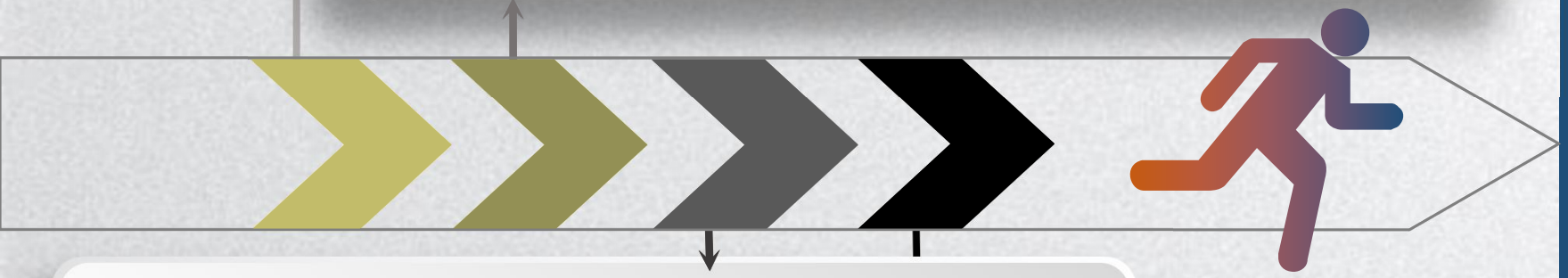


(c)Gain vs. X-ray rate

- 2000 gain in Ar/5% iC_4H_{10}.
- Short term gain evolution about few minutes and no long term gain evolution along time.
- RTGEM gain decrease drastically with increasing X-ray rate. RTGEM with lower resistivity DLC shows better rate capability.

Summary & outlook

1. **DLC-THGEM** shows no Charging-up effect. But gain decrease along irradiation rate.
2. **RTGEM** with DLC electrode were firstly introduced. RTGEM with fast grounding shows good rate capability.
3. **Large area** RTGEM(20cmX100cm) with fast grounding were firstly produced. Gain uniformity 12%.
4. **RWELL** by coupling a single side RTGEM to DLC resistive readout PCB firstly studied.



Much more work to do

- Optimization of
  - DLC parameter
  - Detector structure
  - Working condition
  - Test method
- Simulation works to understand detector behavior …

THANKS

THE END

Back up slides…