Development of Resistive Electrodes for MPGDs

Task 7.3a

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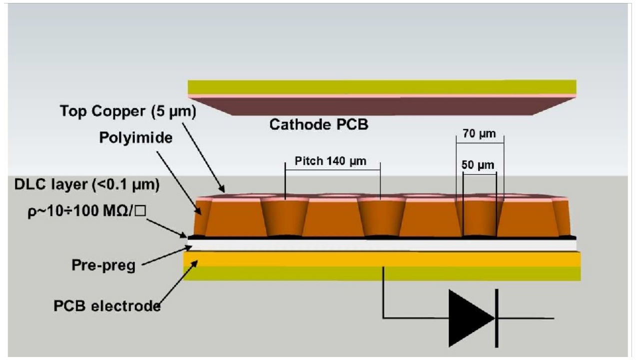
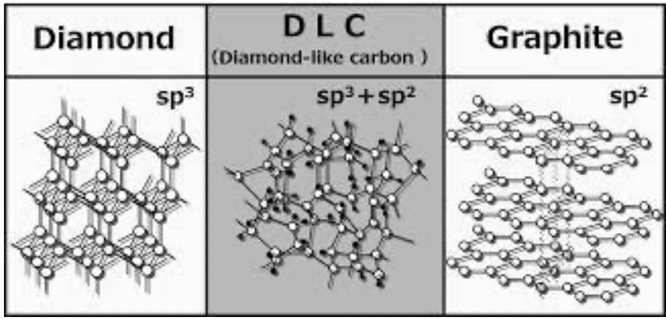
Introduction

Resistive electrodes improve detector stability of single amplification stage MPGDs (micromegas, μRWELL) and might be the bridge to higher gains (reach wire-chambers gain of ~10^5) and stable operation



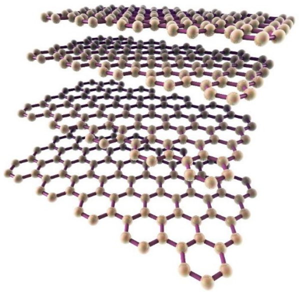
Resistive electrodes can be used for:

- Discharge quenching: *well established*
- Signal charge smearing: *being studied*
- Creation amplification structures: *hard, R&D ongoing*



Diamond Like Carbon (DLC) coating techniques are currently **explored by several groups** to develop new structures and new detectors profiting from coating properties (e.g. robustness, resistivity,…) and on the possibility of controlling them.

Explore **innovative resistive coatings** such as **Multi-Layer Graphene (ML-Graphene)** that are very strong, have high conductance and low material budget



Work within AIDAinnova

Task 7.3. Development of resistive electrodes for MPGDs and Industrial engineering of high-rate μ-RWELL detector

- Production of Diamond Like Carbon (DLC) with ion beam deposition and pulsed laser deposition
- Study of the resistance of graphene to polyimide etching liquids
- Characterisation of 10×10 cm2 foils by DLC and graphene
- Industrial production of small-size prototypes and their characterisation
- Industrial production of large-size prototypes (# 0.5 m2) and their characterisation

Tasks

Task #	Task name	Task Leader
7.3	Development of resistive electrodes for MPGDs and Industrial engineering of high-rate μ-RWELL detector	

MS #	Milestone name	Lead beneficiary	Due Date (in months)	Means of verification
MS26	Production of DLC with ion beam deposition and pulsed laser deposition	21 - INFN	23	Report (Task 7.3)

D #	Deliverable name	Lead beneficiary	Type	Due Date (in months)

AIDA innova

Partners

	Institute	Type	Country	contact person	email
EU beneficiaries	INFN Bari	Research Institute	Italy	Piet Verwilligen	piet.verwilligen@ba.infn.it
	INFN Lecce			Annapoala Caricato	annapoala.caricato@le.infn.it
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EU non-beneficiaries (collaborating institutes)	CNR Nanotec	Research Institute	Italy	Giuseppe Valerio Bianco	giuseppevalerio.bianco@cnr.it
	CNR IFN			Gaetano Scamarcio	gaetano.scamarcio@cnr.it

Benificiaries:

- INFN Bari: Ion Beam Deposition DLC, Detector Design & Testing, Task Leader
- INFN Lecce: Pulsed Laser Deposition DLC
- INFN Pavia: Detector Testing

AIDA innova collaborators (not included in Proposal, but essential contributors):

- CERN: Micro-Pattern Technology (MPT) Workshop: Rui De Oliveira

Collaborating Institutes:

- CNR Nanotec (Bari) ML-Graphene Deposition, ML-Graphene Etching
- CNR IFN (Bari) Photo-Lithography, Patterning

Futher possibilities *(already ongoing collaboration within INFN R&D activities)*

- CNR Nanotec (Lecce) Photo-Lithography, Patterning, DLC Etching

Non-EU close contacts: USTC (Hefei, CN) – Magnetron Sputtering - Resistive DLC collab RD51

R&D on DLC Electrodes

High-Resistive GEM with DLC electrodes

- Pulsed Laser Deposition (PLD) and Ion Beam Deposition (IBD) of DLC on Polyimide
- *in first year the work concentrated on the production of DLC - only*
- **In the second year we moved on towards creation of DLC – Cu sandwich**
- For etching tests to be feasible we scaled up the size
- - for PLD deposition from 1cm^2 to 5 x 5 cm^2
- - for IBD deposition from 5 x 5 cm^2 to 10 x 10 cm^2
- **Most of last year's activity was concentrated on obtaining the right recipe for the Etching tests**
- *- depostion of multilayers without vacuum breaking*
- *- transport under vacuum to avoid Cu-oxidation*
- *- increase of Cu-layer to 500nm for better adherence to final 7um Cu layer created through Electroplating*

- *Milestones:* Report delivered at month 23
- *Deliverables:* none

MS26	Production of DLC with ion beam deposition and pulsed laser deposition	WP7	7.3	M23	28/02/2023	Achieved	Report

DOI 10.5281/zenodo.7690626

Milestone Report @ mth 23

Production of DLC with ion beam deposition and pulsed laser deposition

A.P. Caricato; A. Valentini; P.Verwilligen

Diamond-Like Carbon (DLC) resistive layers are a key ingredient for increasing the rate capabilities of Micro-Pattern Gaseous Detectors (MPGDs). Their production method and related quality is studied by ion beam deposition and pulsed laser deposition. The current DLC sample size will be scaled up gradually to 10×10 cm^2, their quality is assessed for the production of detector-grade amplification structures.

Preview

Page: 1 of 22 Automatic Zoom

Grant Agreement No: 101004761

AIDAinnova

Advancement and Innovation for Detectors at Accelerators
Horizon 2020 Research Infrastructures project AIDAINNOVA

MILESTONE REPORT

PRODUCTION OF DLC WITH ION BEAM DEPOSITION AND PULSED LASER DEPOSITION

Indexed in OpenAIRE

Publication date: February 28, 2023

DOI: DOI 10.5281/zenodo.7690626

Keyword(s): WP7

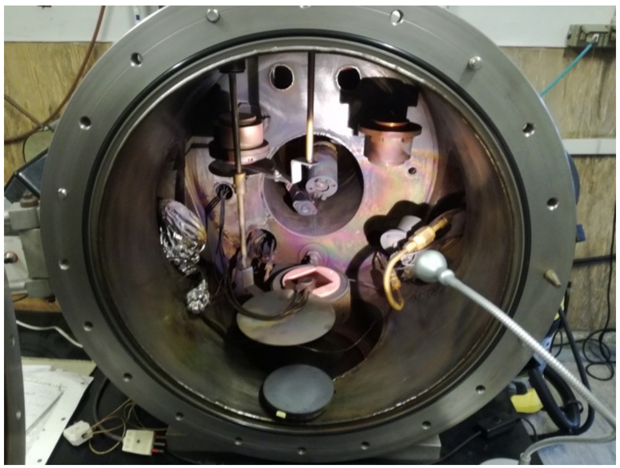
Grants:
European Commission:
- AIDAinnova - Advancement and Innovation for Detectors at Accelerators (101004761)

Communities: AIDAinnova

22 pages – 15 figures – Introduction to various PVD techniques for DLC

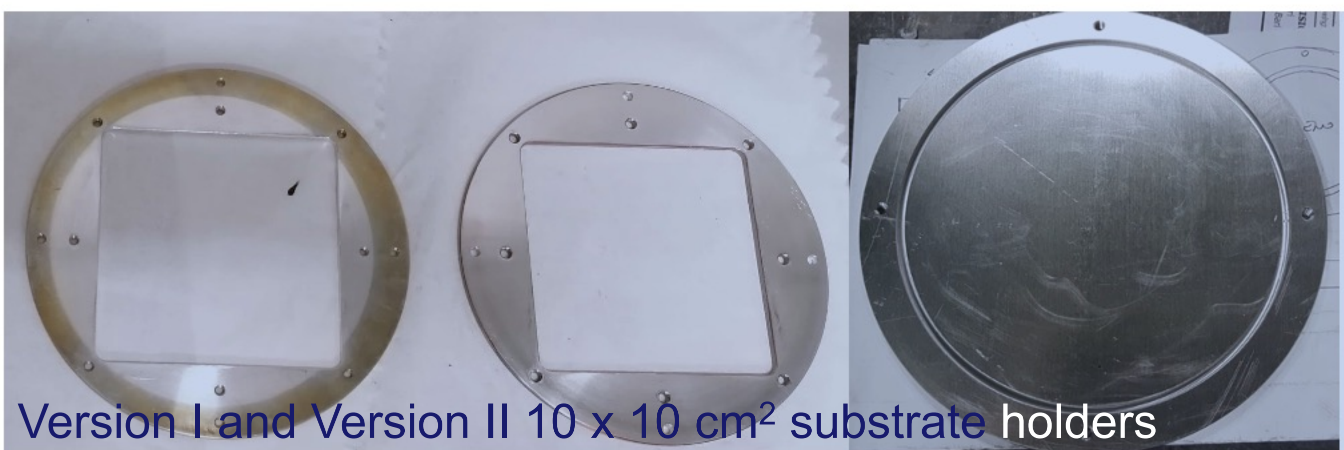
Ion Beam Sputter Deposition

- Obtained correct recipe for 100MOhm/sq DLC covered by 500nm Cu layer
- Scaled up production to 10x10 cm^2



Tab. 2 Parameters for main and assistance ion beam sources for the deposition of a multi-layer DLC-Ti-Cu film

		Main ion source			Assistance ion source				Notes	
	step	V_{beam}	I_{beam}	Ar	V_{beam}	I_{beam}	Ar	H_2	time	thickness
1	PI cleaning	-	-	-	150V	1A	5.1 sccm	4.0 sccm	300s	-
2	DLC layer	800V	50mA	2.5sccm	80V	50mA	7.3 sccm	2.0 sccm	7200s	50 nm
3	DLC cleaning	-	-	-	150V	1A	5.1 sccm	-	300s	-
4	Ti interlayer	1300V	35mA	2.5sccm	-	-	-	-	1260s	10 nm
5	Cu layer I	1000V	50mA	2.5sccm	-	-	-	-	720s	30 nm
6	Cu cleaning	-	-	-	150V	1A	5.1 sccm	-	300s	-
7	Cu layer II	1200V	60mA	2.5sccm	-	-	-	-	8520s	470nm

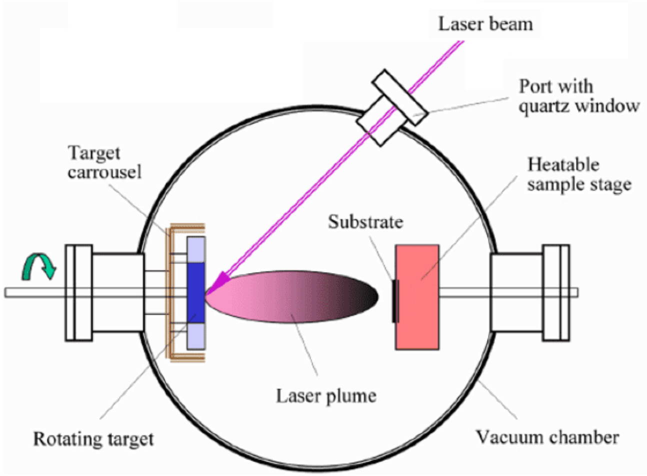


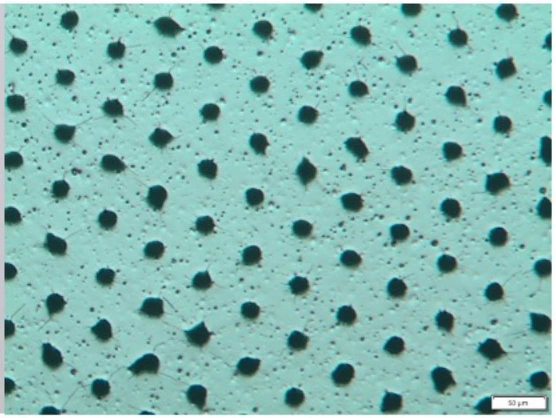
Version I and Version II 10 x 10 cm^2 substrate holders

10x10 cm^2

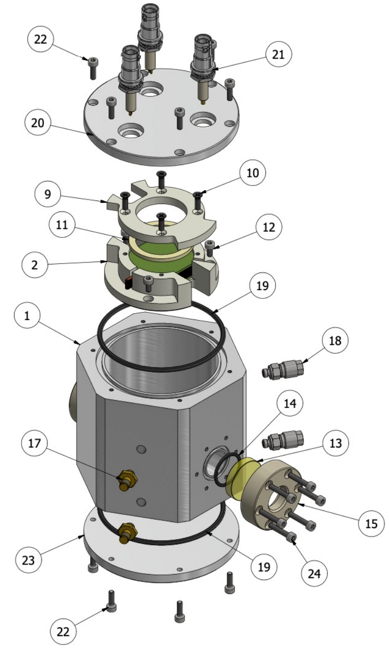
Pulsed Laser Deposition

- Obtained correct recipe for 100MOhm/sq DLC covered by 500nm Cu layer
- Scaled up production to 5x5 cm^2
- Several failed Etching tests
  - Understood due to delamination of final 7um Cu layer made through electroplating on top of original 100nm of Cu made through PLD
- Solution
  - increase to 500nm Cu thickness through PLD
  - shipment under vacuum
- Finally good detector-grade DLC foil produced
- Many thanks to CERN MPT workshop



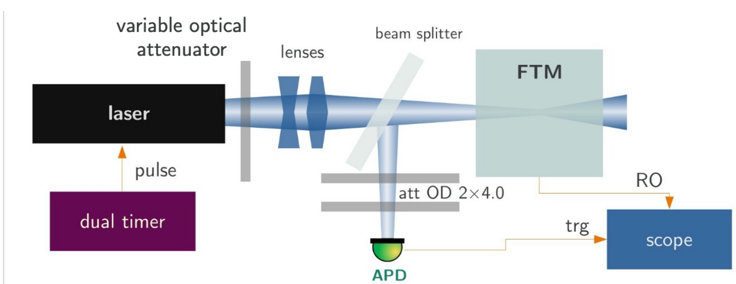


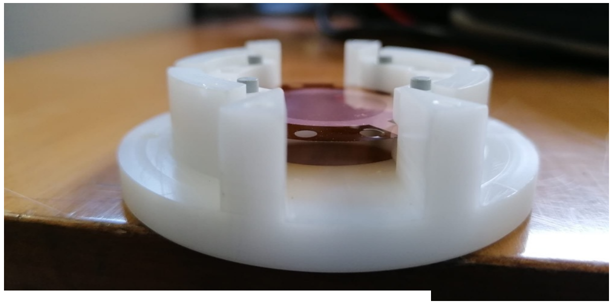
Test of the DLC foil

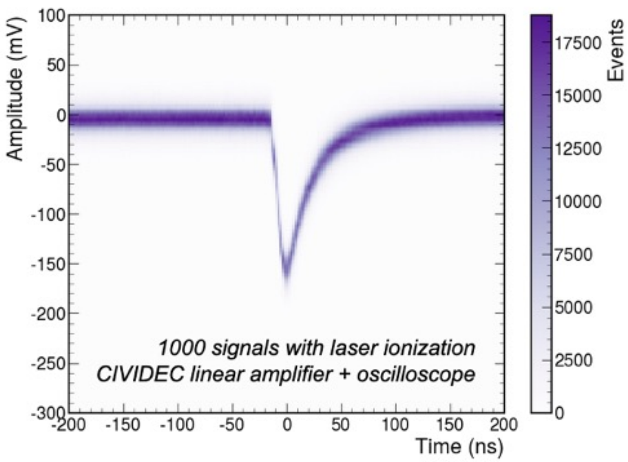


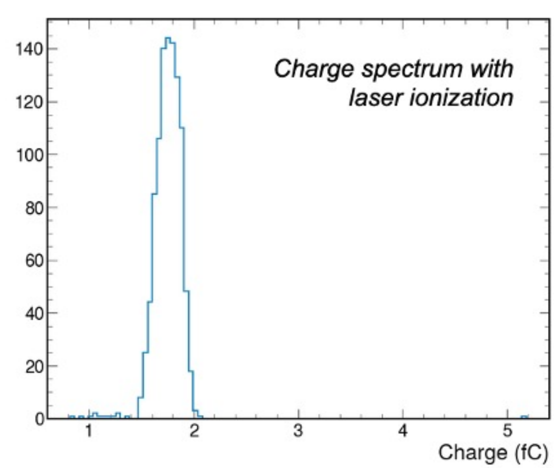
Test of the DLC foil inside the small-size detector

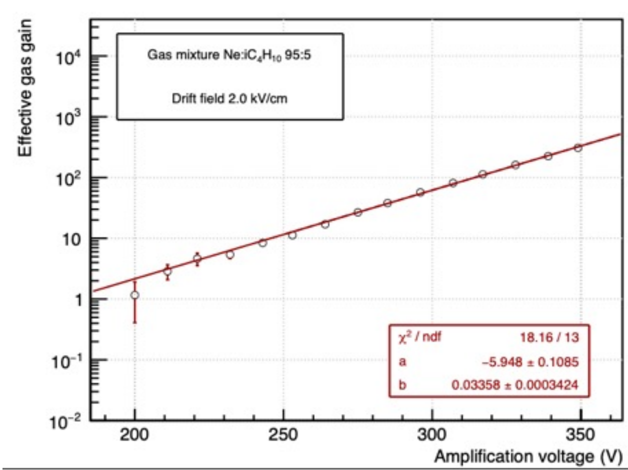
- has both quartz (UV-laser) as mylar (^{55}Fe) window
- Stable operation under 450V in $Ar:CO_2:iC_4H_{10}$ 93:5:2
- Signals clearly visible (150mV) and 1.75fC
- Gain up to 500 measured – not bad for a first production foil











Summary / Outlook

- Progress was made with the Etching Tests of the PLD and IBSD DLC foils
- A First 5x5 cm^2 foil was succesfully etched after several failed attempts
- A detector-grade foil was produced and tested inside the detector
- Milestone report MS26 was written and reviewed in time