Ion Beam Induced Deposits of Pt:

Composition, Vol/dose and electrical transport properties

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Outline

- Dual beam equipment in Zaragoza (Spain): Induced deposition
- Pt IBID deposition: Composition, Vol/dose
- Transport measurements
  - As a funtion of T
  - During deposition: microprobes

Results shown: *De Teresa et al, Microelectronical engineering, submitted*
Preprint available on request

Dual Beam in Zaragoza

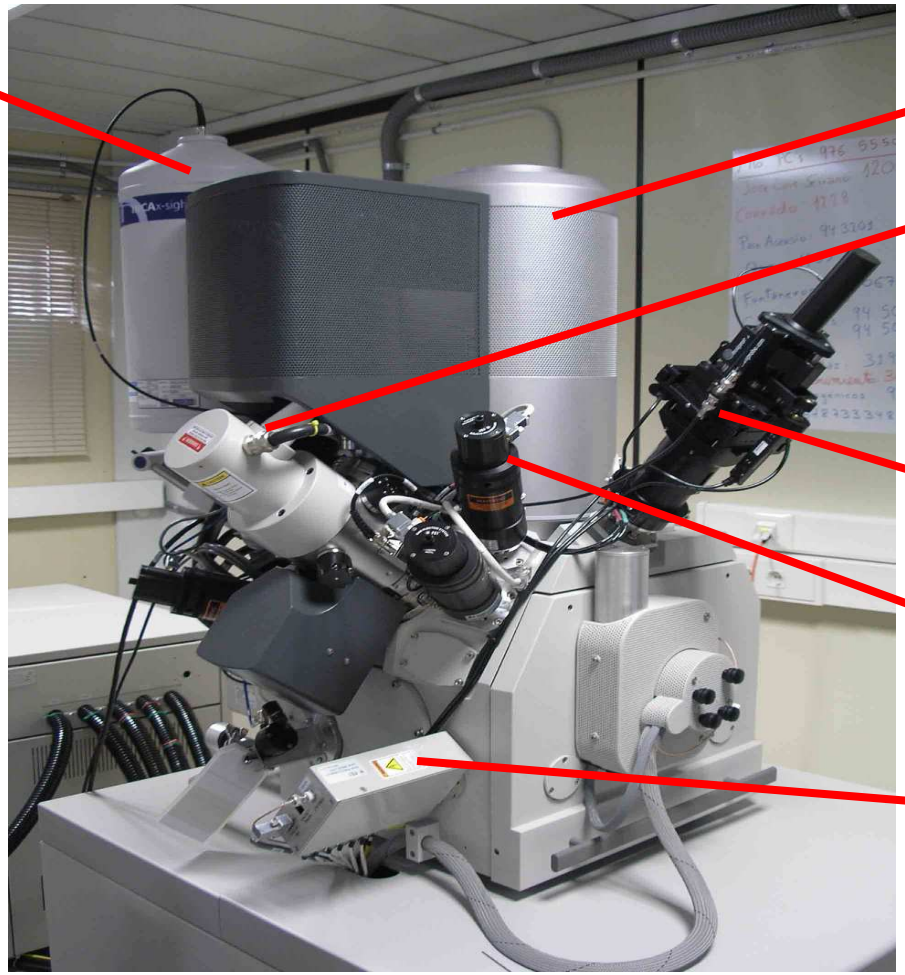
Nova 200 NanoLab by FEI

EDX DETECTOR (Oxford Instruments)

STEM DETECTOR (not visible)

EBL LITHOGRAPHY (Raith Elphy Plus) (not visible)

4 MICROPROBES FOR ELECTRICAL MEASUREMENTS (not visible)



FEG 30 keV ELECTRON COLUMN

30 keV Ga^{+3} ION COLUMN

TLD (THROUGH-LENS) DETECTOR (secondary and backscattered electrons)

OMNIPROBE NANOMANIPULATOR

5 GAS INJECTORS (GIS)

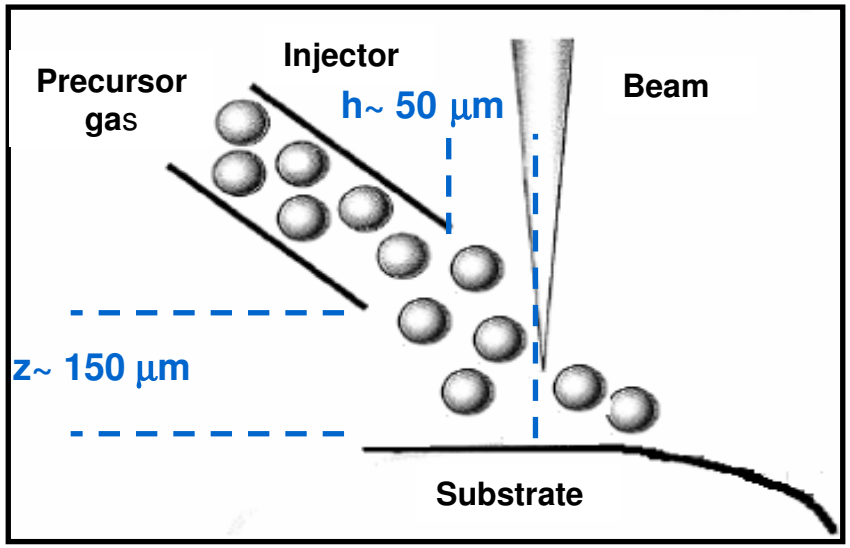
CDEM DETECTOR (secondary ions and electrons)

Ion & electron beam induced deposition

IBID & EBID of metallic materials **is one major application of dual beam systems:**

Controllable lateral size (EBID~5nm; IBID ~1-10nm) & thickness (10nm-10µm)

Applications: Reparation of optical masks & integrated circuits, fabrication of 3d-nanostructures, protection layers for lamella preparation, creation of electronic devices, fabrication of nanoelectrodes & nanocontacts, transport studies of NW, etc



Process: Beam "breaks" the molecules, inducing a deposit (CVD)

Materials in Zaragoza:

METAL	GAS
Pt	$(CH_3)_3Pt(CpCH_3)$
W	$W(CO)_6$
Co (only EBID)	$Co_2(CO)_8$

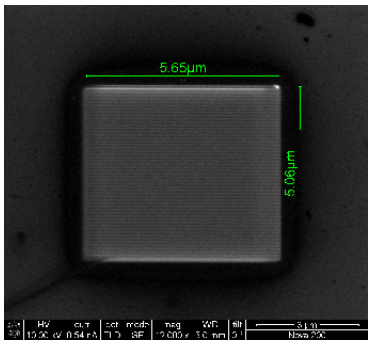
Problems:
- **High ρ (amorphous carbon matrix)**
- **Ga implantation (IBID)**

Pt IBID- OBJECTIVE

High conductivity deposits are desired!!

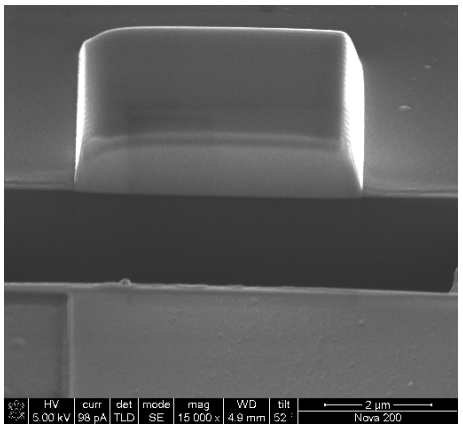
IBID depositions in 5 x 5 mm^2 areas on a Si substrate- influence of:

- **Ion current: 100pA- 2.5nA**
- **Beam energy: 5- 30keV**



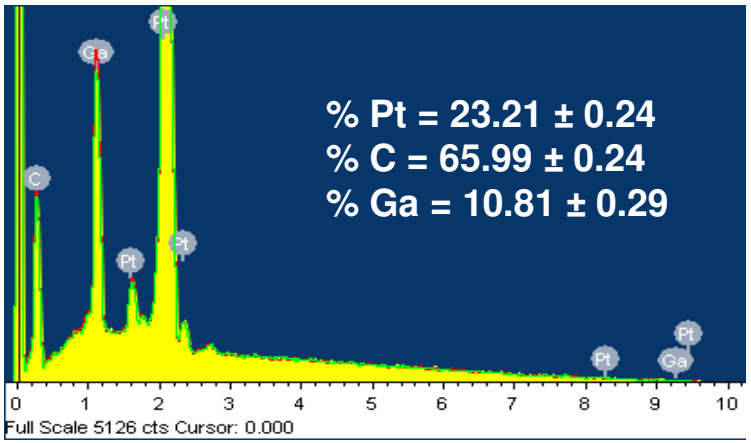
7keV, 1.8nA

Study of the Vol/dose (cross sections)



20keV, 0.21nA

Study of the Pt content (EDX analysis)



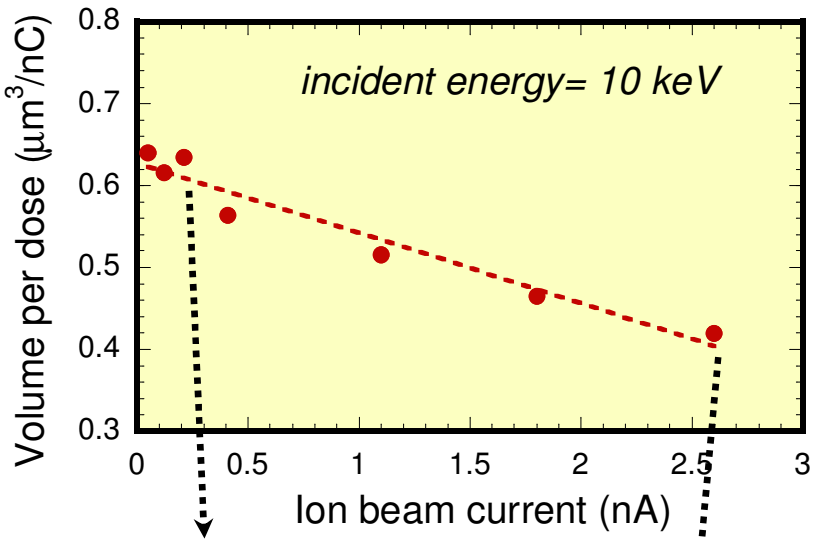
20keV, 0.21nA

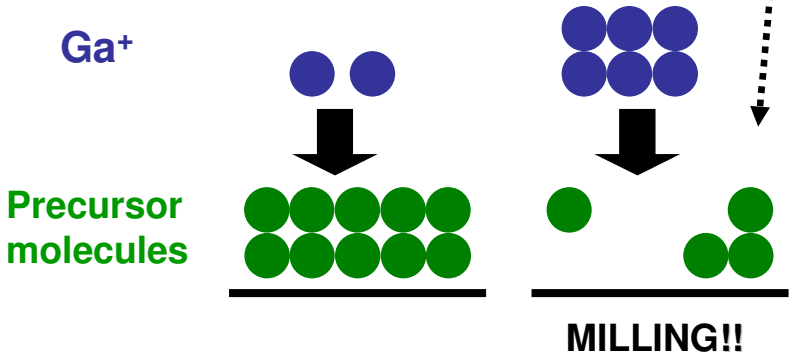
Study of the resistivity

- **R(Temperature) *ex situ***
- **R(time) *in situ***

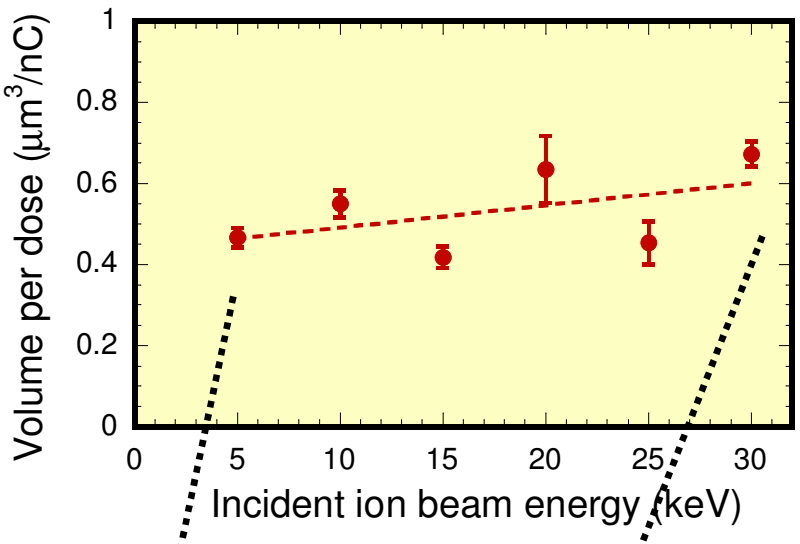
Pt IBID: Vol/dose

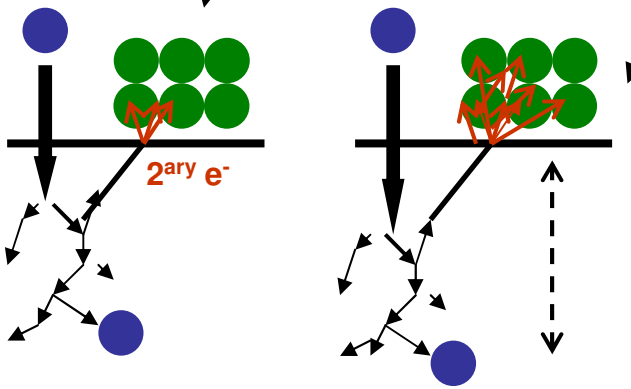
Vol/dose (current) decreases from 0.65 down to 0.45µm^3/nC





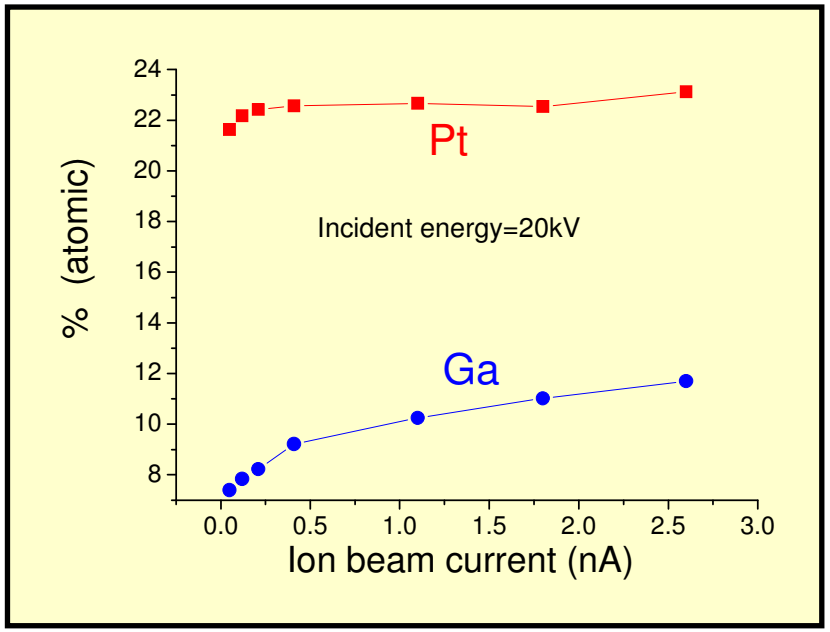
Vol/dose (beam energy) increases sligthtly



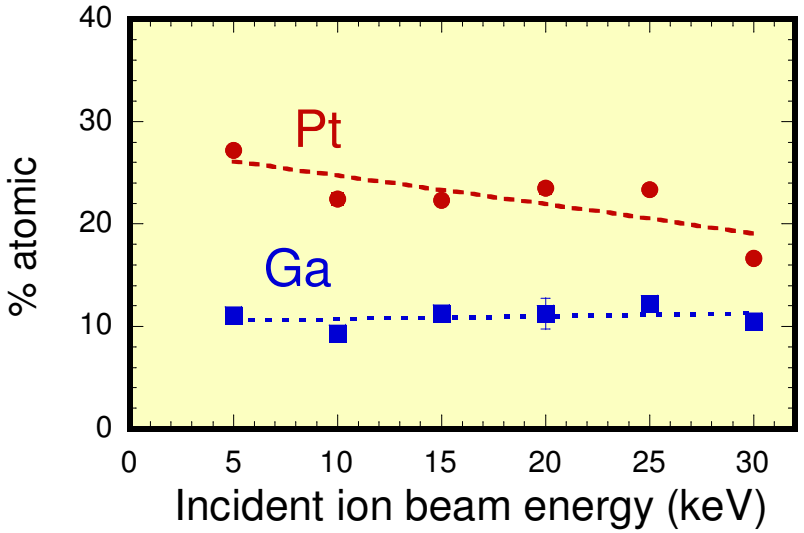


Pt IBID: Pt content

Pt content (current) ~ constant



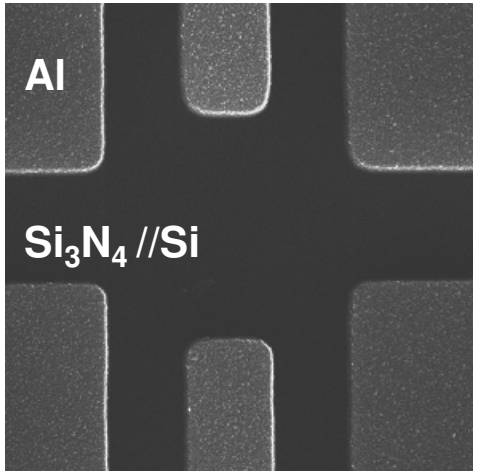
Pt content (beam energy)
decreases from 27% down to 17%.
[TRIM: Pt sputtering yield increases]

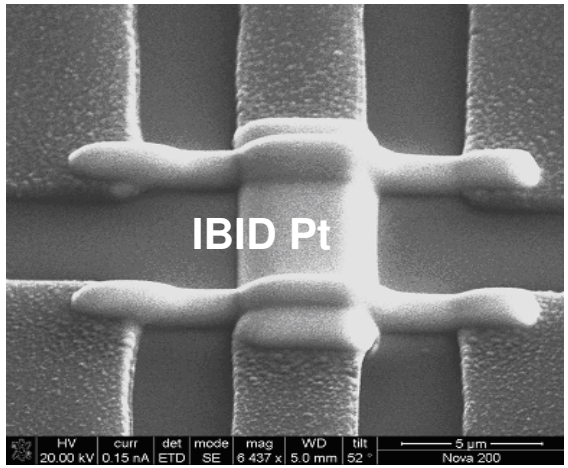


Ga content (beam energy) increases sligthly (from 8% up to 12% at 20kV)
[MILLING]

Ga content (beam energy) ~10%
[TRIM: Penetration depth of Ga^+ ~constant]

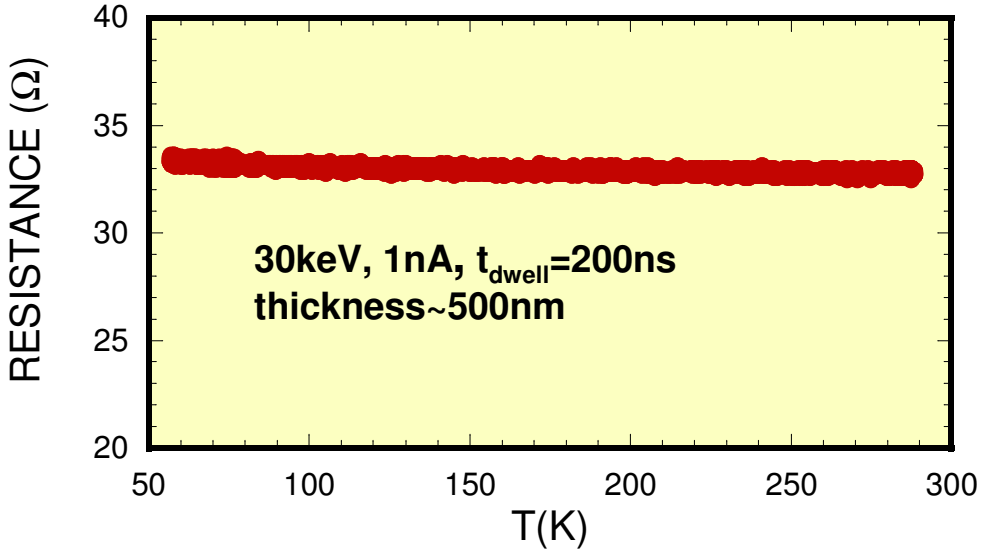
Transport measurements: resistance as a function of T





Optical lithographyŁ 12 µm gap between metal electrodes.

FIB deposits permit 4W electrical measurements

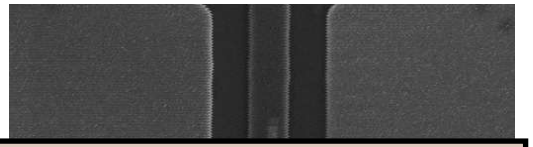


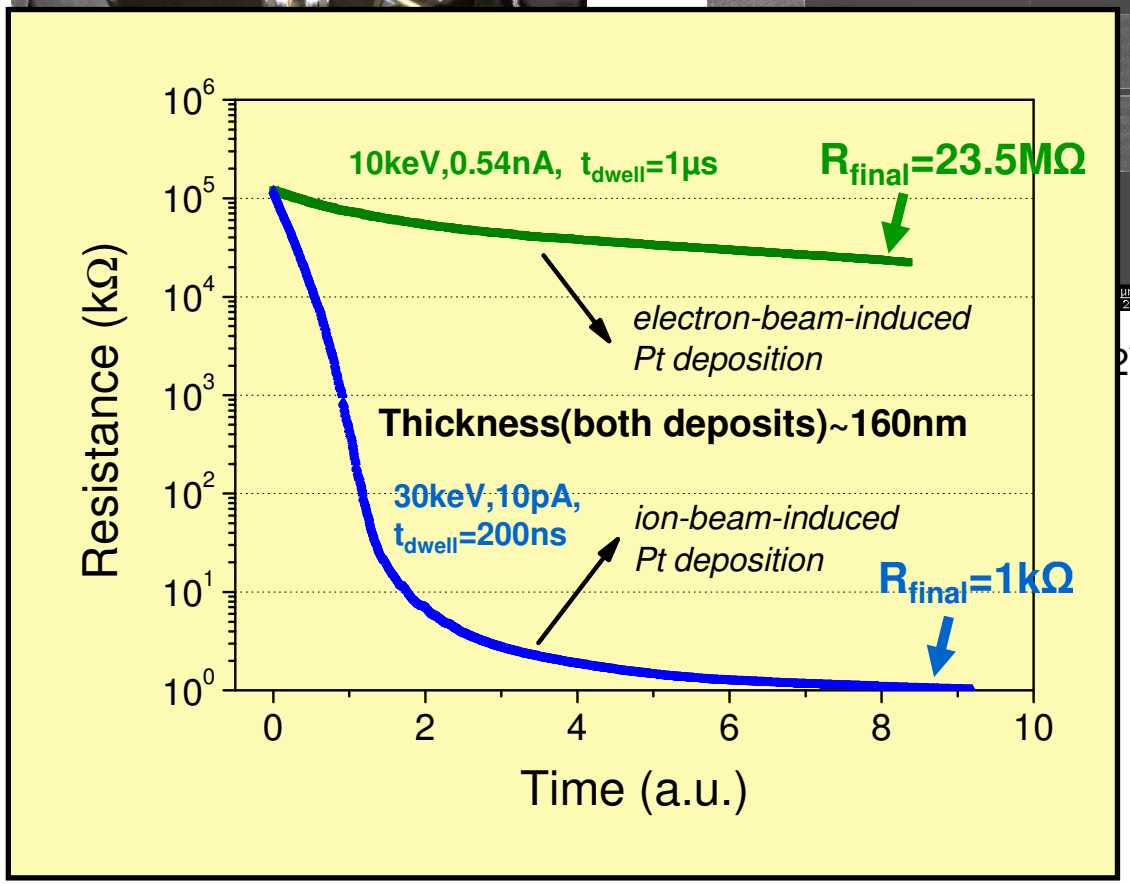
R weakly dependent on temperature.

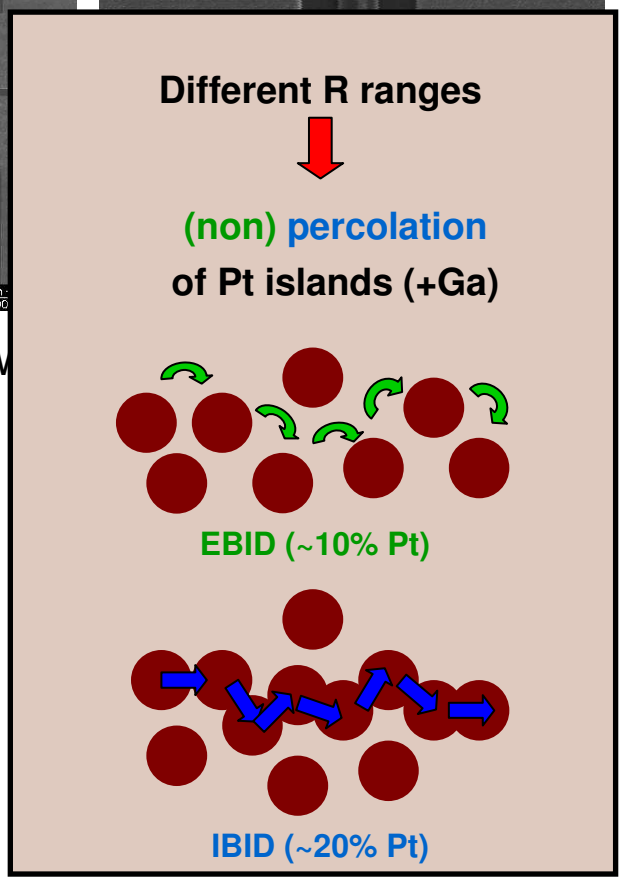
ρ≈ 500 µΩ·cm:

Lower than other values reported in literature but still 50 times higher than bulk Pt

Transport measurements: *in situ* control of the resistance







CONCLUSIONS & OUTLOOK

Study as a function of E_{beam} & I_{beam} of Pt- ion induced deposits

- Vol/dose (current) decreases (milling increases)
- Vol/dose (beam energy) increases sligthly (more SE generated)
- %Pt (current) ~ constant
- %Ga (current) increases sligthly (milling increases)
- %Pt (beam energy) decreases (sputtering yield of Pt increases)
- %Ga (beam energy) ~ constant (interaction volume does not change much)

Preliminary transport results

- ρ≈ 500μΩ·cm (50 times larger than bulk Pt)
- R weakly dependent with temperature
- Possible to measure *in situ* the resistance during deposition

Next…

- Study of different parameters: t_{dwell}, $t_{refresh}$, gas flux,…
- Annealing procedures to increase Pt content
- Sistematic study of ρ, 4W in situ measurements, …