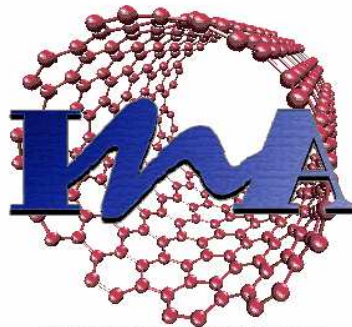


# Ion Beam Induced Deposits of Pt:

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 function of T
  - During deposition: microprobes

Results shown: *De Teresa et al, Microelectrical 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**

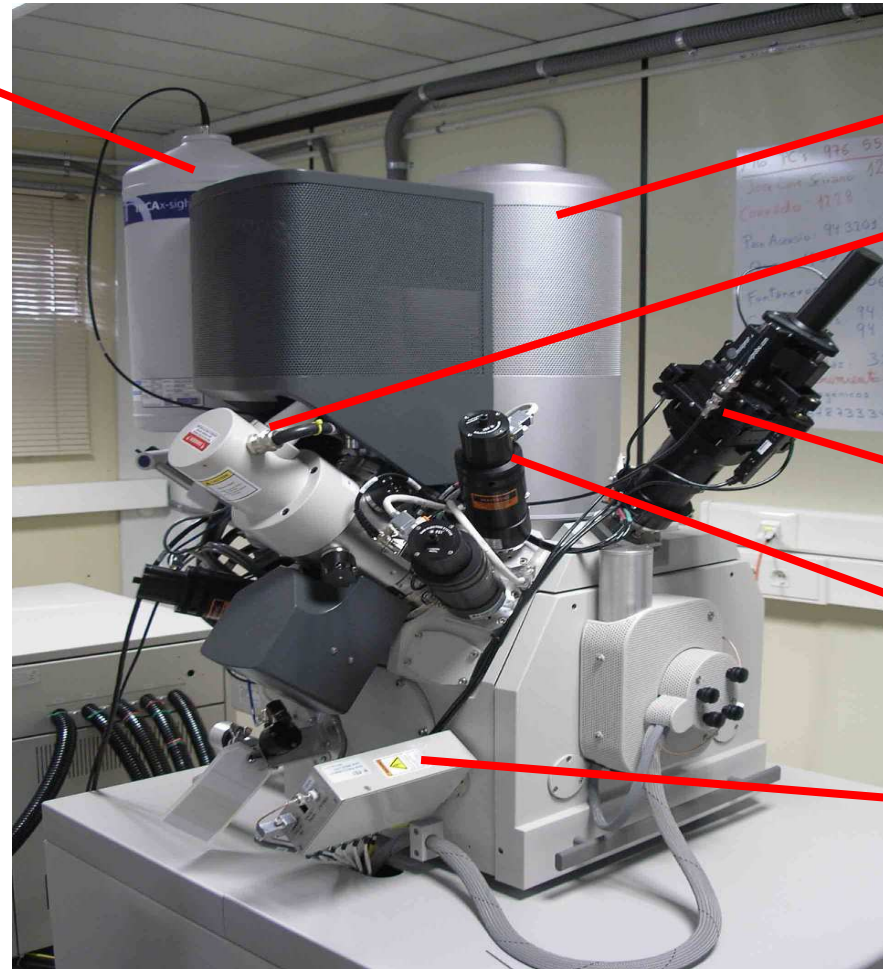
**30 keV Ga<sup>+3</sup> ION COLUMN**

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

**OMNIPROBE NANOMANIPULATOR**

**5 GAS INJECTORS (GIS)**

**CDEM DETECTOR**  
(secondary ions and electrons)

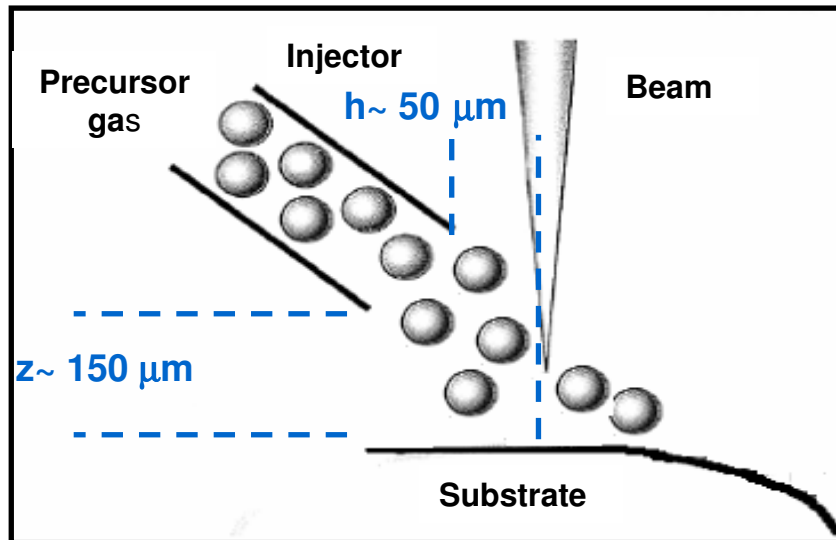


# Ion & electron beam induced deposition

**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	$(\text{CH}_3)_3\text{Pt}(\text{CpCH}_3)$
W	$\text{W}(\text{CO})_6$
Co (only EBID)	$\text{Co}_2(\text{CO})_8$

**Problems:**

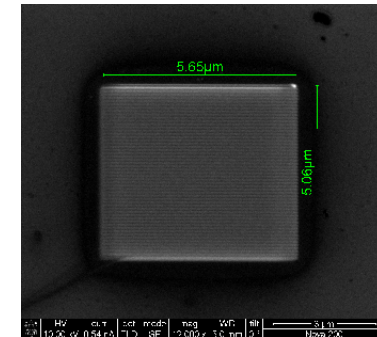
- High  $\rho$  (amorphous carbon matrix)
- Ga implantation (IBID)

# Pt IBID- OBJECTIVE

High conductivity deposits are desired!!

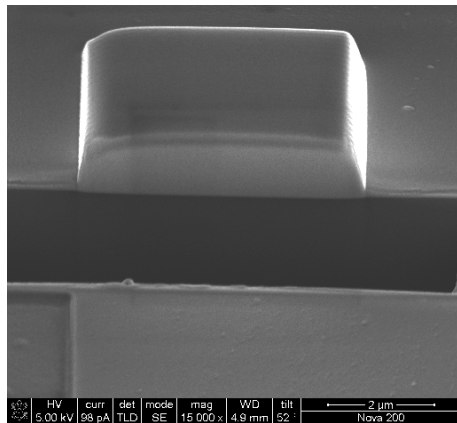
**IBID depositions** in 5 x 5 mm<sup>2</sup> areas on a Si substrate- influence of:

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



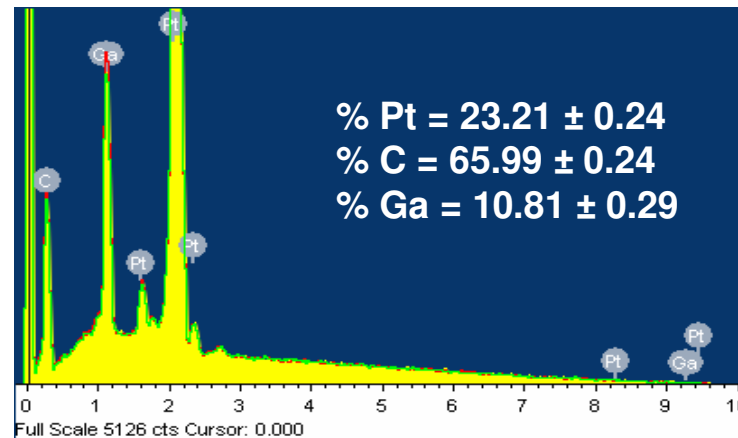
7keV, 1.8nA

Study of the **Vol/dose**  
(cross sections)



20keV, 0.21nA

Study of the **Pt content**  
(EDX analysis)



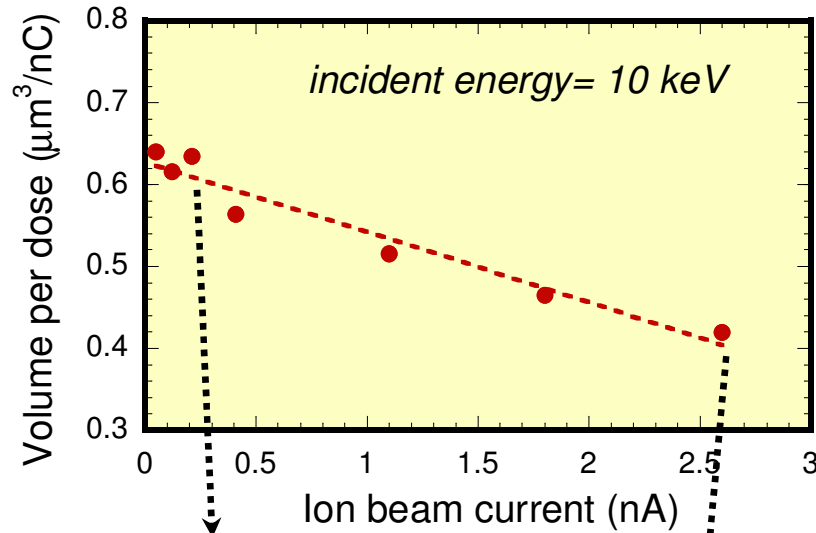
20keV, 0.21nA

Study of the **resistivity**

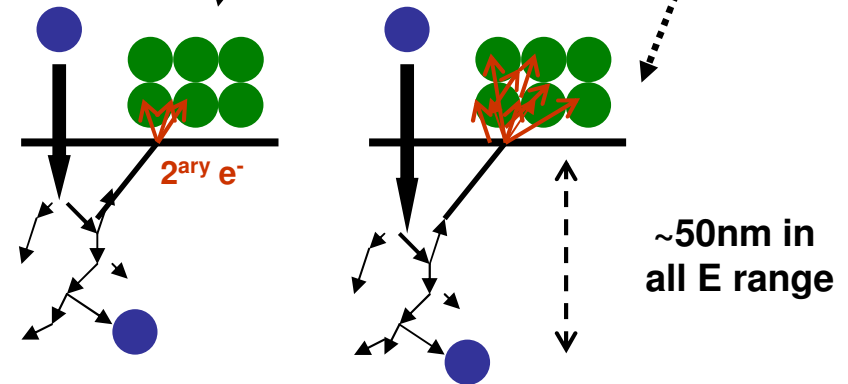
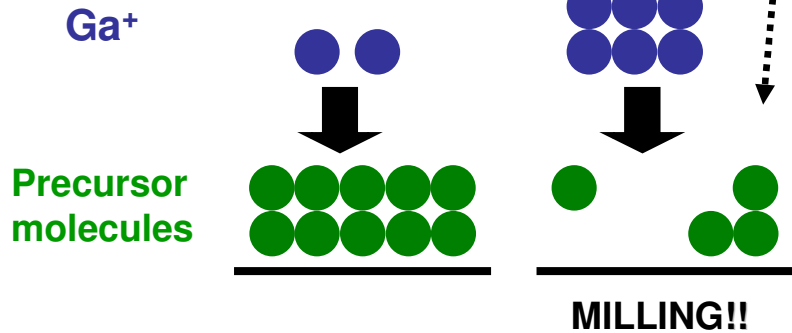
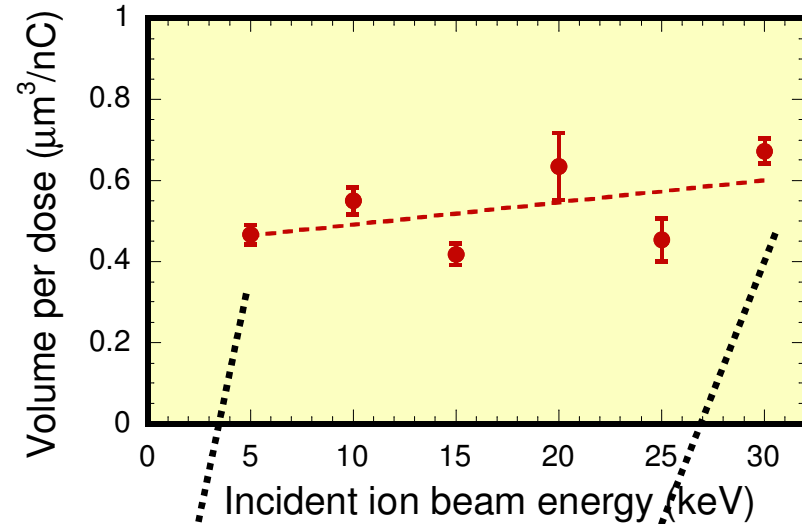
- R(Temperature) *ex situ*
- R(time) *in situ*

# Pt IBID: Vol/dose

**Vol/dose (current)** decreases from 0.65 down to 0.45  $\mu\text{m}^3/\text{nC}$

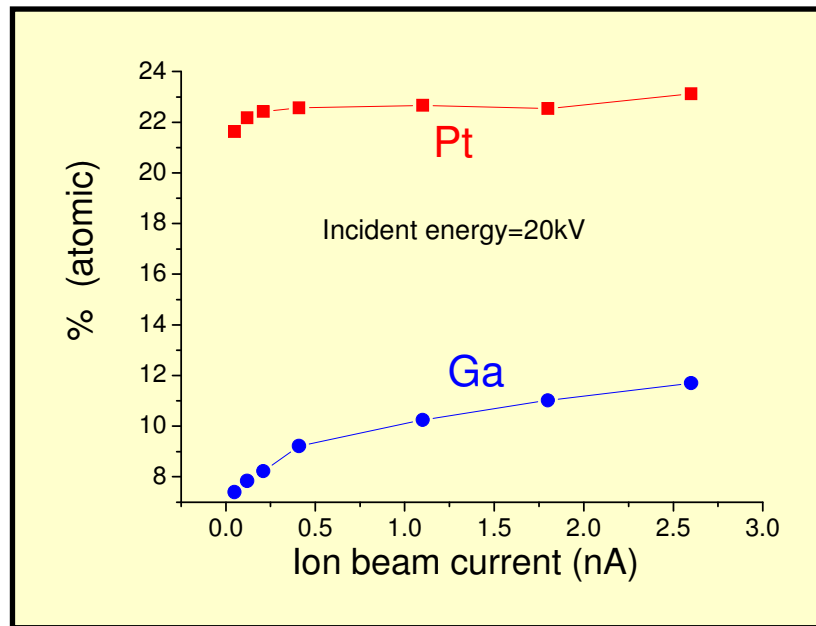


**Vol/dose (beam energy)** increases slightly



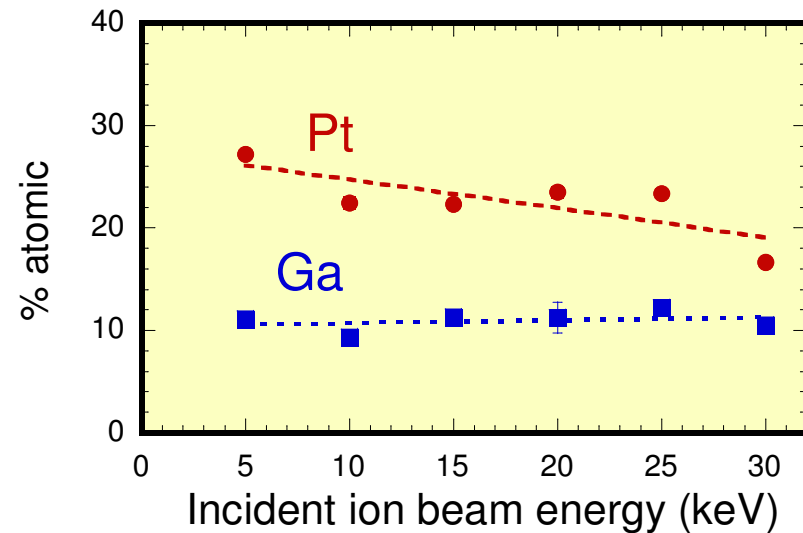
# Pt IBID: Pt content

**Pt content (current) ~ constant**



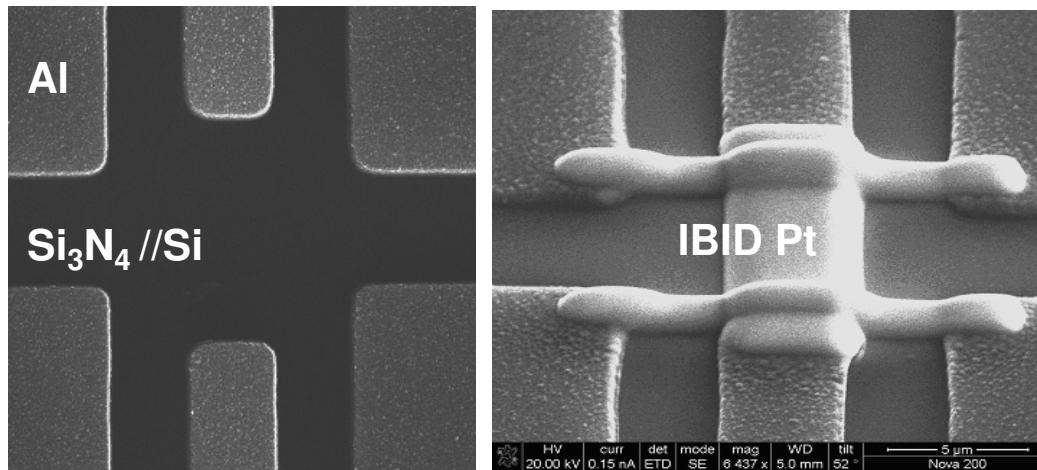
**Ga content (beam energy) increases slightly (from 8% up to 12% at 20kV)**  
[MILLING]

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



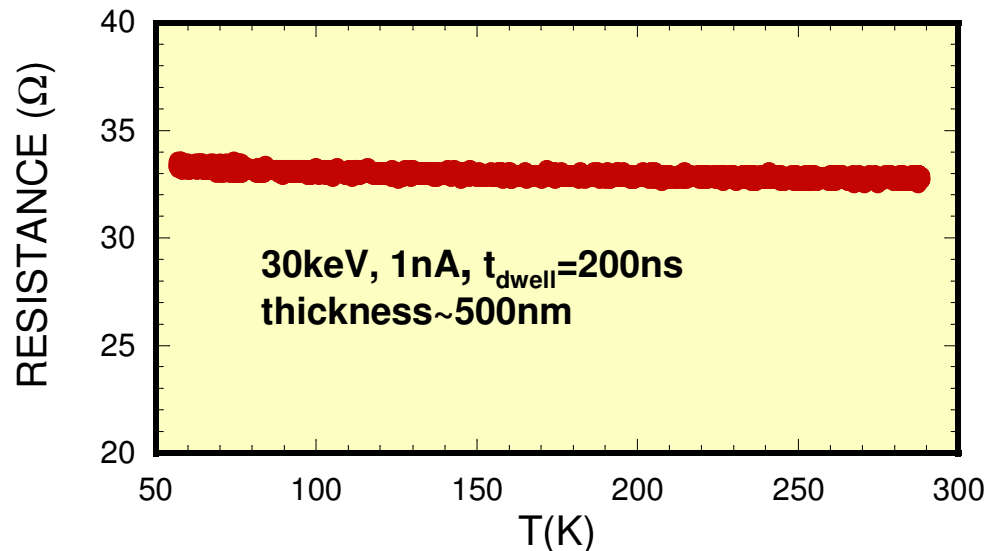
**Ga content (beam energy) ~10%**  
[TRIM: Penetration depth of Ga<sup>+</sup> ~constant]

# Transport measurements: resistance as a function of T



**Optical lithography** 12 μm gap between metal electrodes.

**FIB deposits** permit 4W electrical measurements

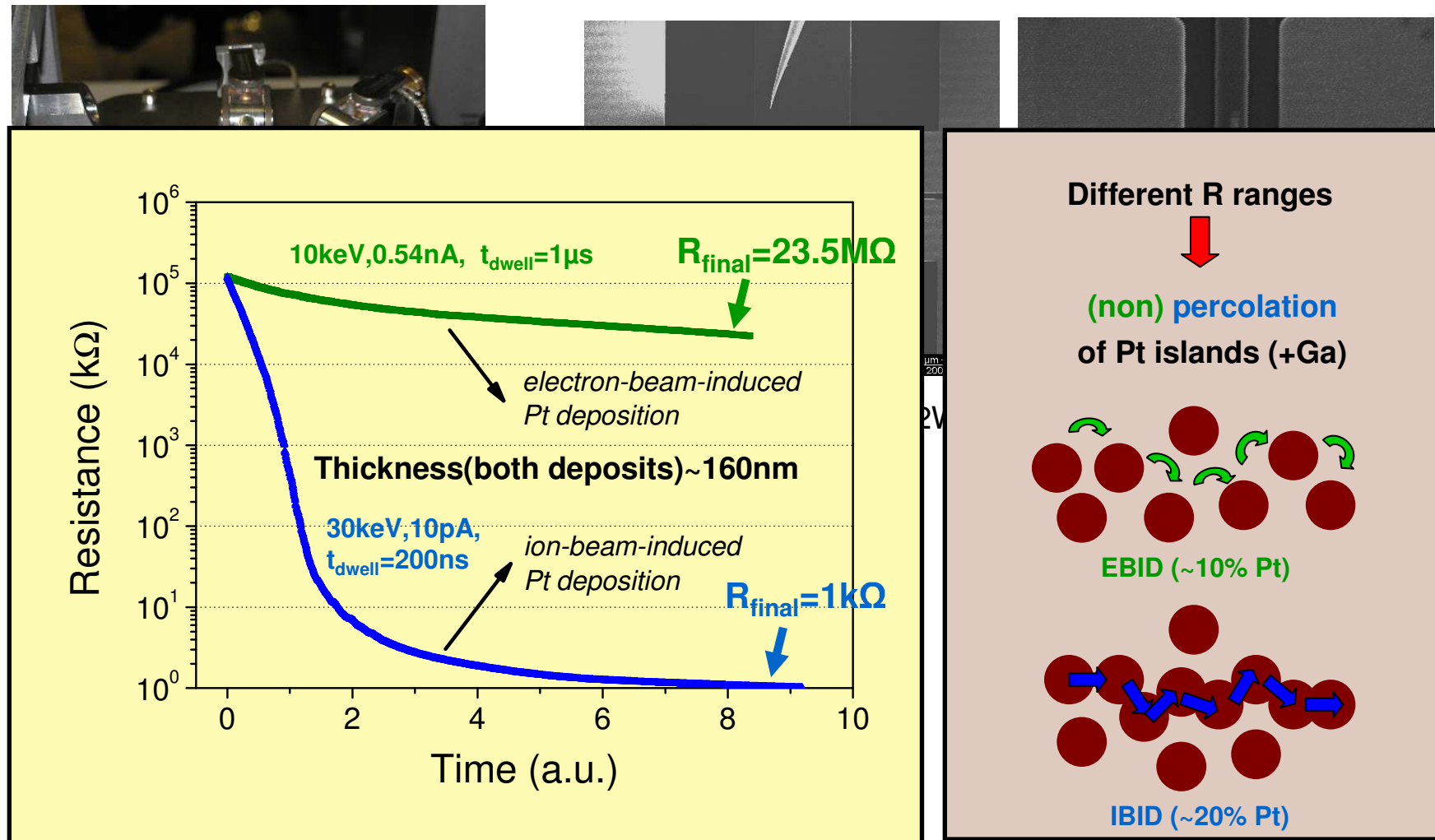


**R weakly dependent on temperature.**

**$\rho \approx 500 \mu\Omega \cdot \text{cm}$ :**

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 $E_{\text{beam}}$ & $I_{\text{beam}}$ of Pt- ion induced deposits

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

## Preliminary transport results

- $\rho \approx 500 \mu\Omega \cdot \text{cm}$  (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:  $t_{\text{dwell}}$ ,  $t_{\text{refresh}}$ , gas flux, ...
- Annealing procedures to increase Pt content
- Systematic study of  $\rho$ , 4W in situ measurements, ...