Focused ion beam for charge transport characterization along Si and SiC nanocrystals in SiO_2

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OUTLINE

- Introduction
- SiC nanocrystal layers
- FIB technology
- Electrical and optical characterization
- Looking for an explanation
- Conclusions

Introduction

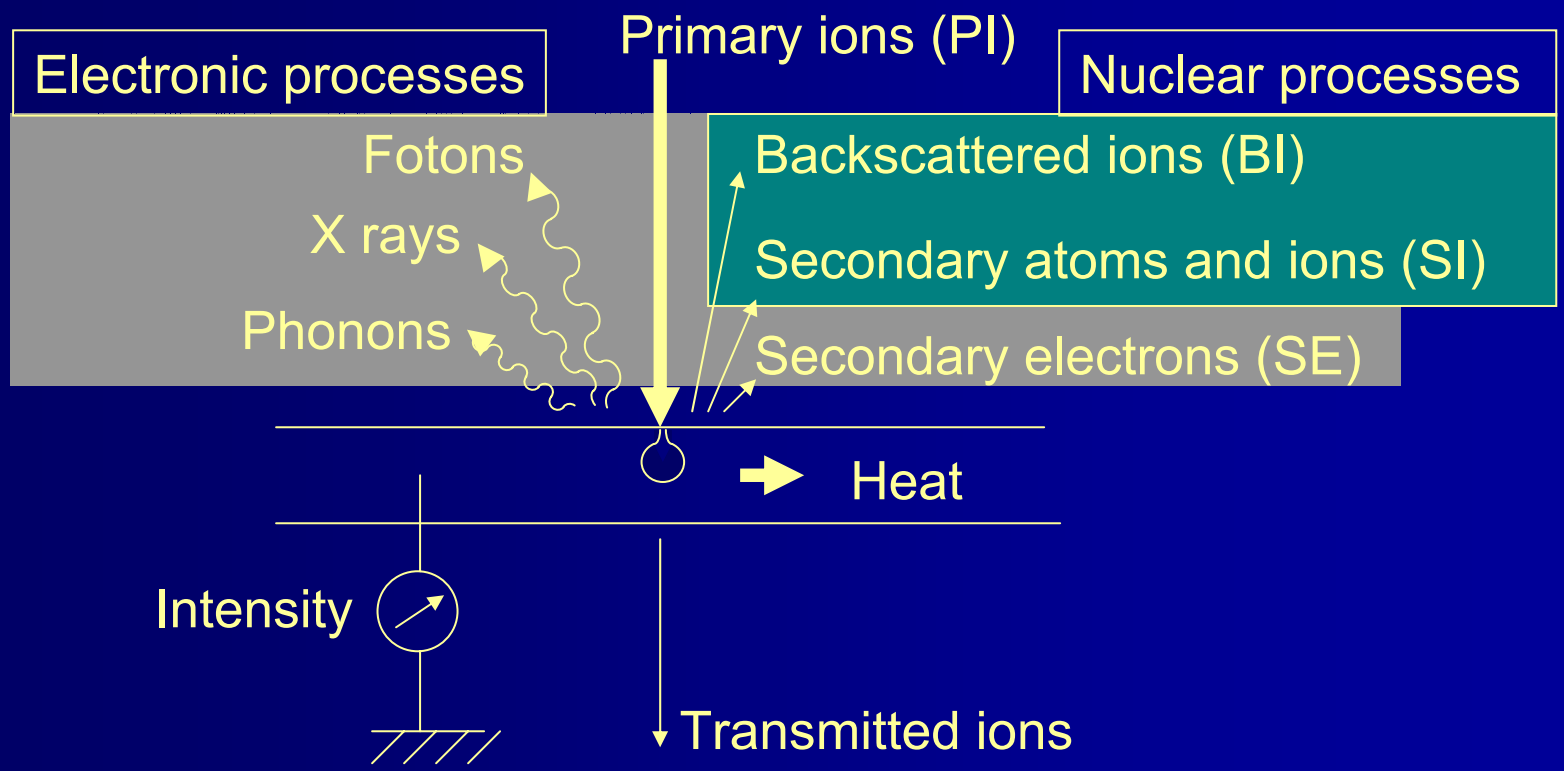
- *Si and SiC nanoparticle-rich oxides ⇒ interesting for their luminescent properties.*
- *They present a broad white PL ⇒ possibilities in optoelectronic devices such as multicolour active displays.*
- *C-related PL bands ⇒ very short lifetime (~100ps) interesting for fast switching devices.*

⇓

- *Fabrication of optoelectronic devices ⇒ good knowing and control of transport properties.*
- *Usual Capacitor structures are not sufficient for this type of characterization ⇒ interest for a longitudinal transport structure.*
- *Nanotechnology ⇒ Focused Ion Beam (FIB)*

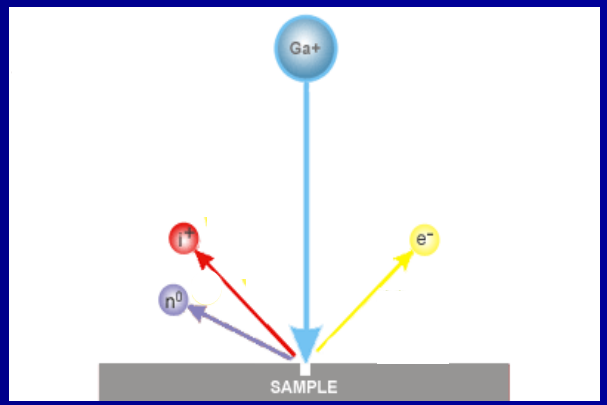
Introduction to FIB

An ionic beam over a sample changes its chemistry (ionic implantation), topology (sputtering), structure (defects), electronic properties (doping).

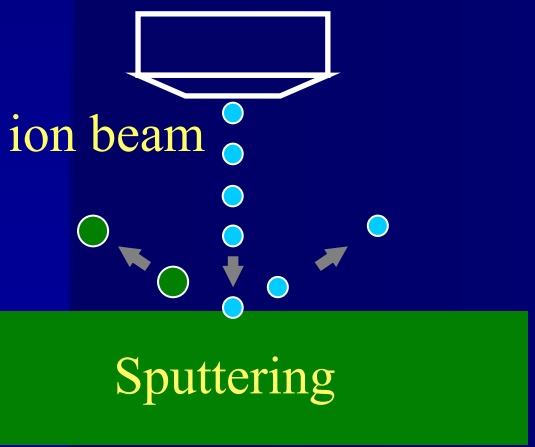


FIB realization

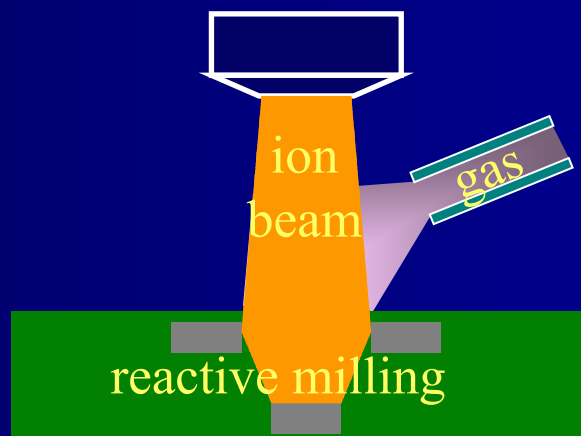
FIB consists on the bombardment of a sample with primary energetic ions (usually Ga+), producing:



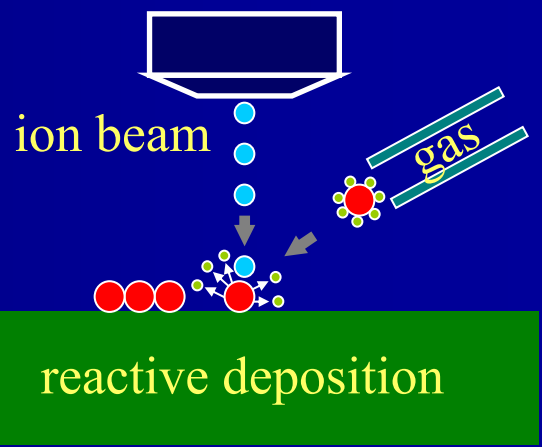
sputtering



IEE

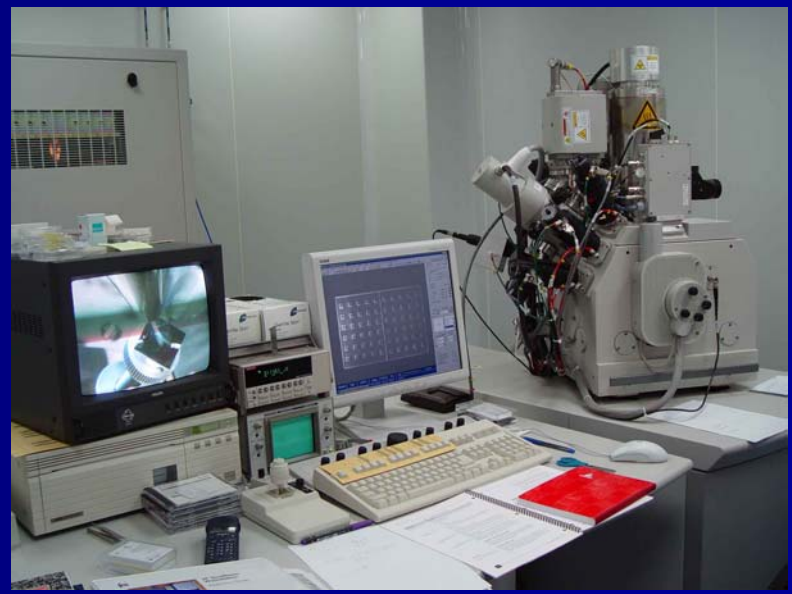


IACVD



Experimental

- FEI Strata235 Dual Beam
- Ga+ beam at 30 kV and I ranging from 1 to 30 pA
- e- beam up to 5 kV at 52º from the ion beam
- Synchronized imaging
- Gases for IACVD of SiO_2, Pt, W, and IEE of organic compounds



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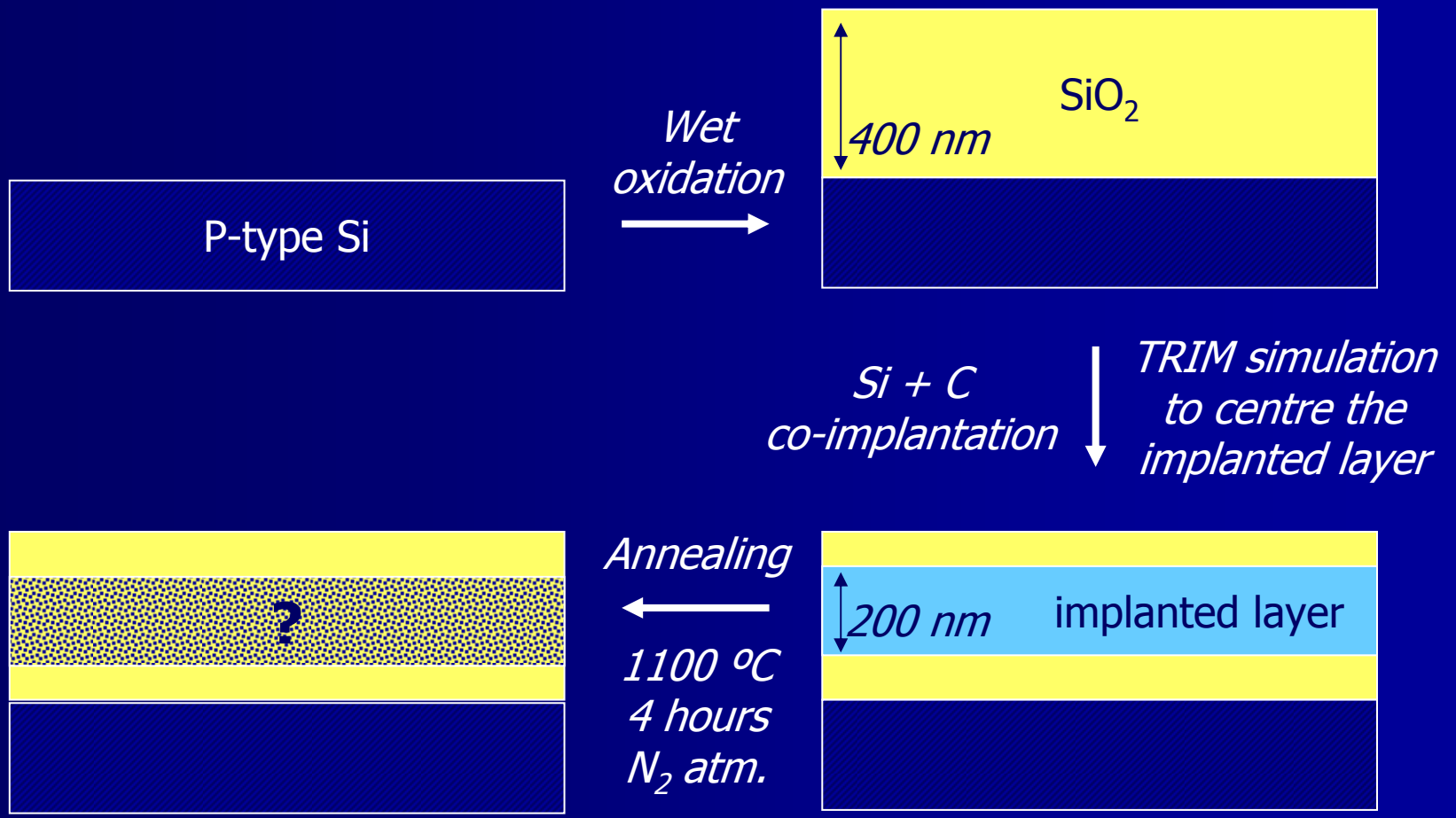
SiC nanocrystal layers



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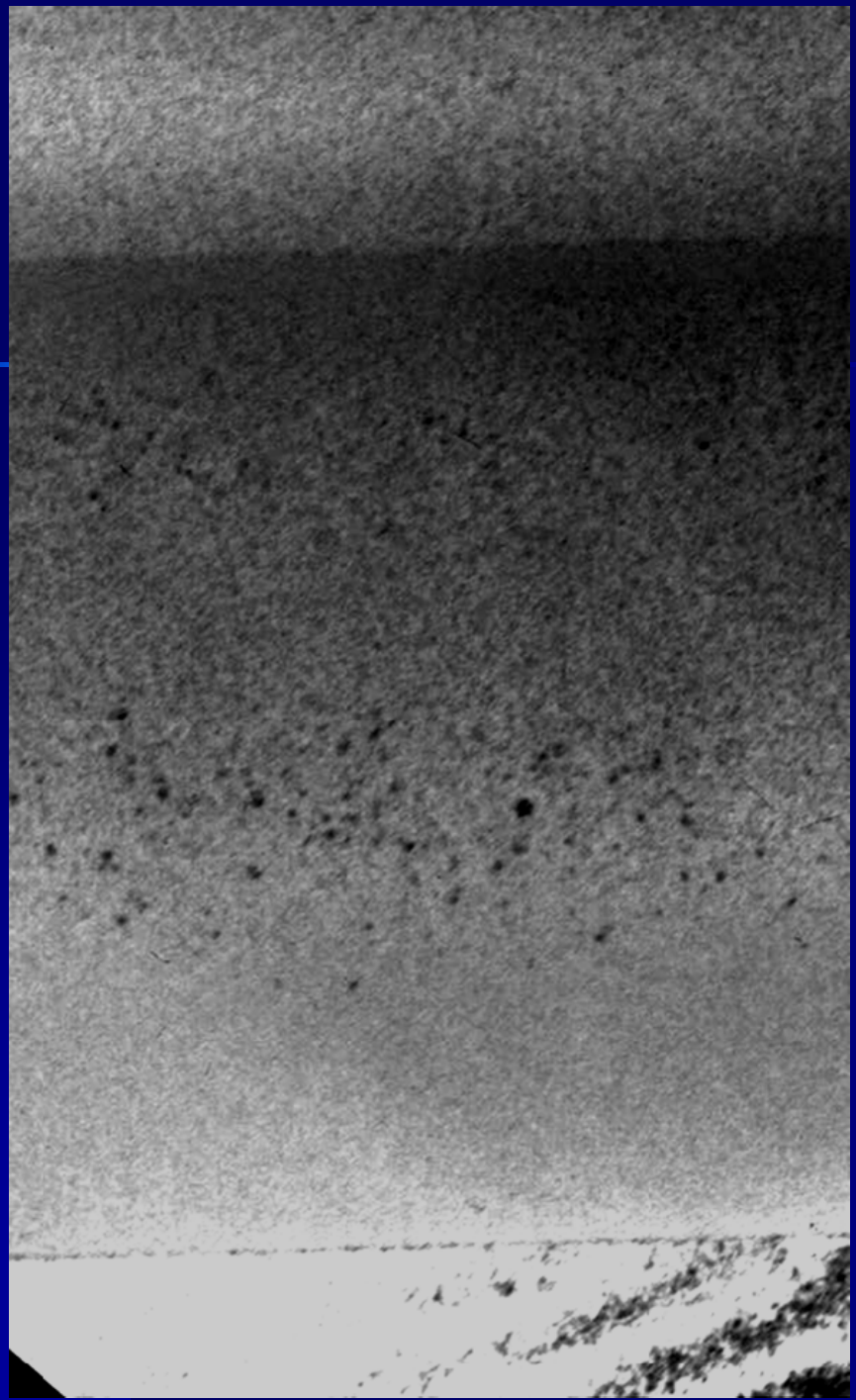
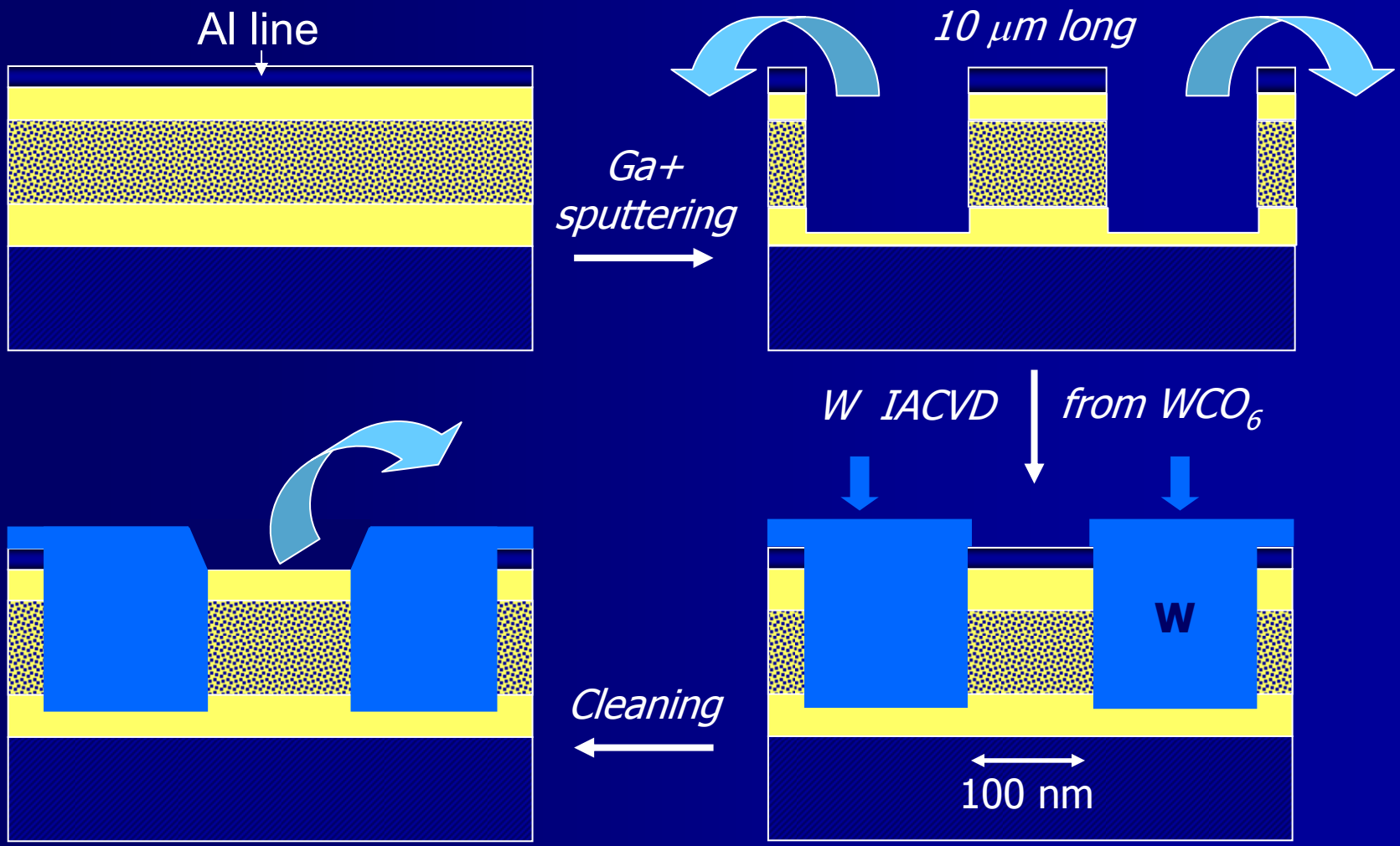
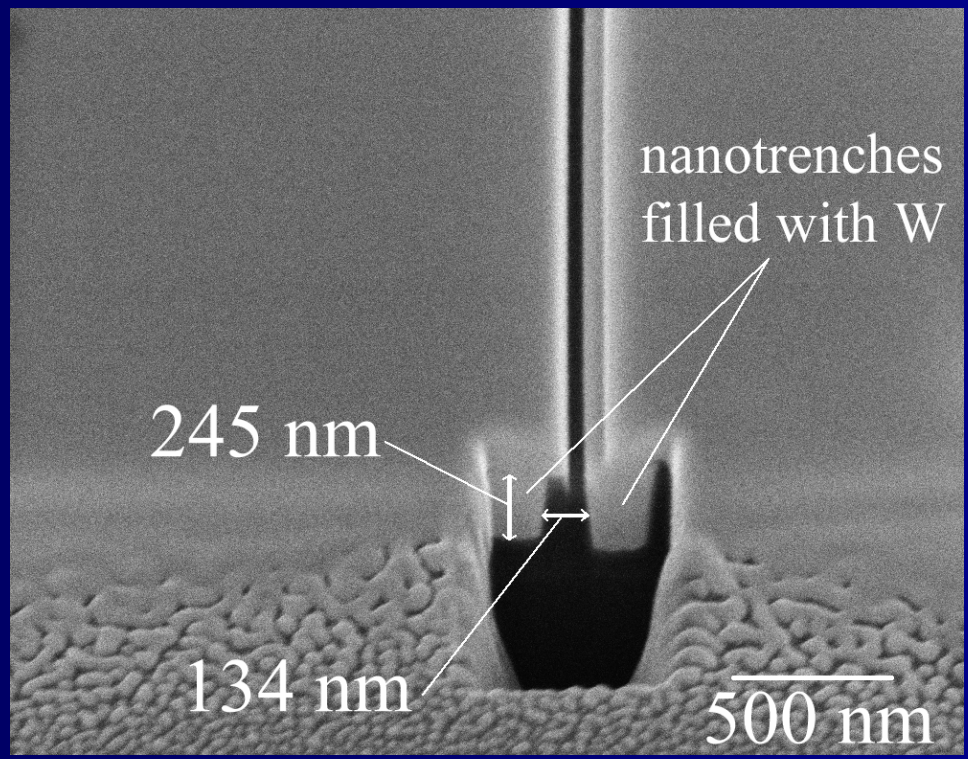
TEM characterization



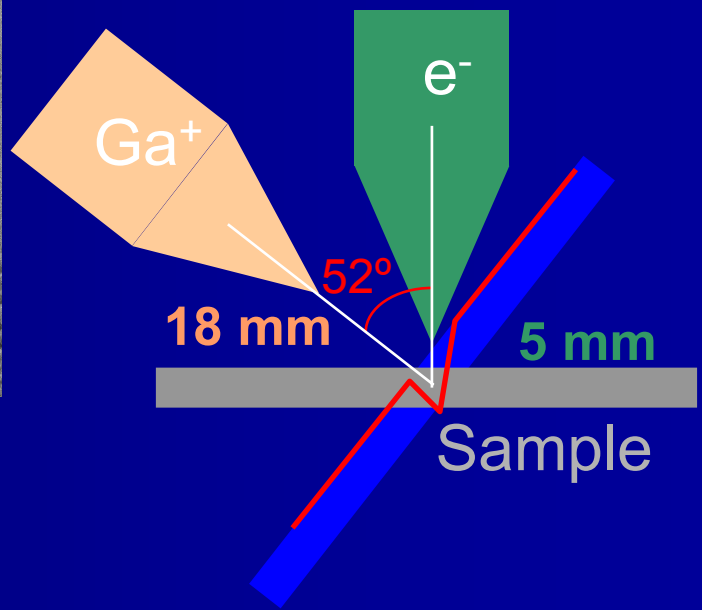
FIB technology



In situ cross section & SEM imaging



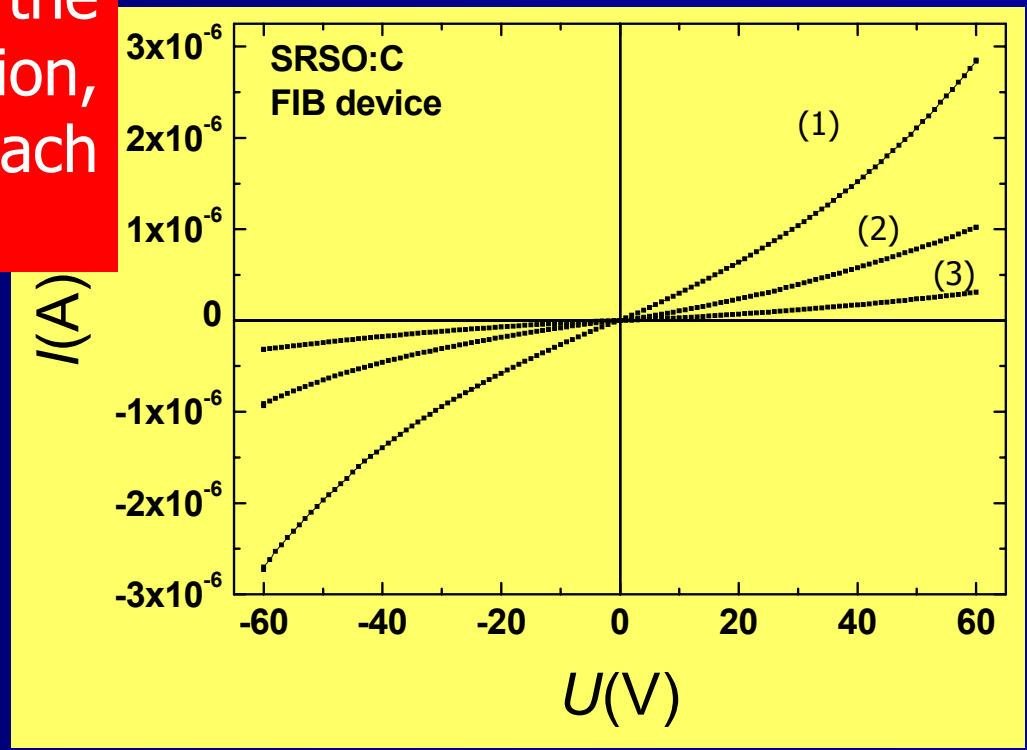
Viewing at 52° by *in situ* cross section and e- imaging



Electrical and optical characterization

- I-V shows an irreversible increase of the resistivity after each measurement.

Carrier retention in the nanoparticle-rich region, increasing with each measurement.



(1) first sweep to 60 V,
(2) second sweep and
(3) after 30 min at 30 V.

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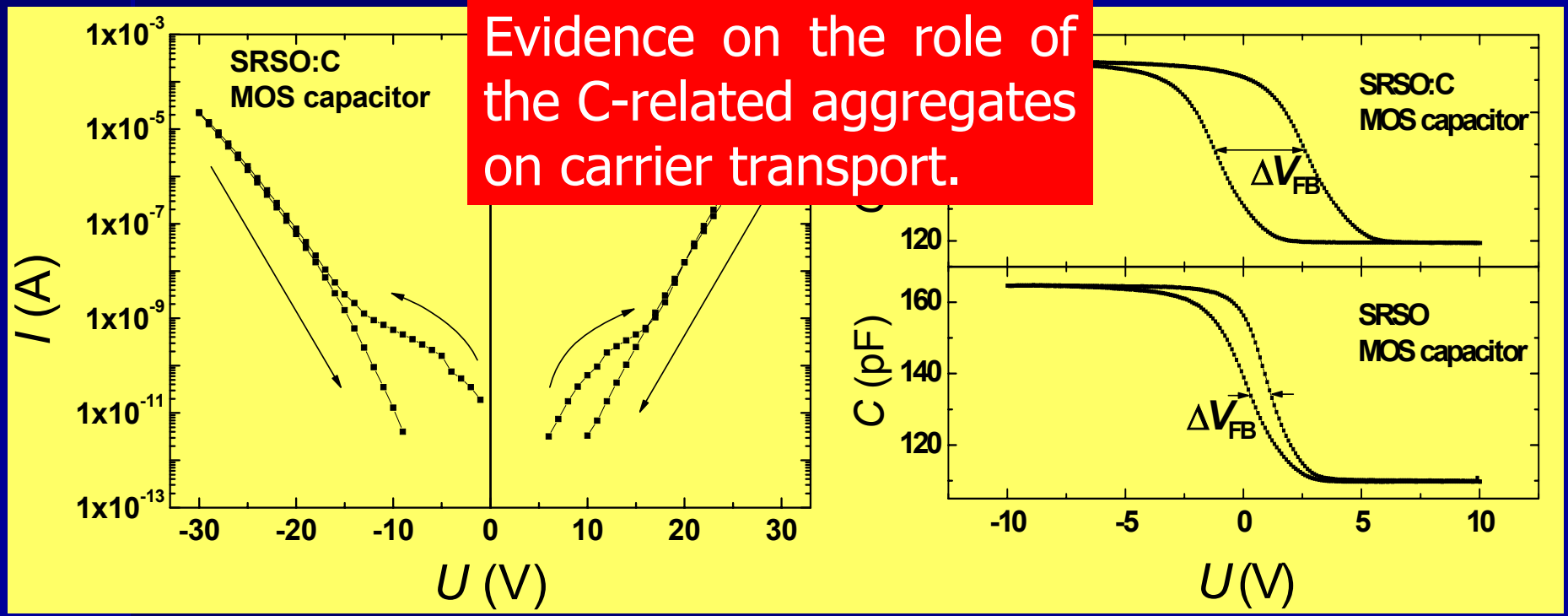
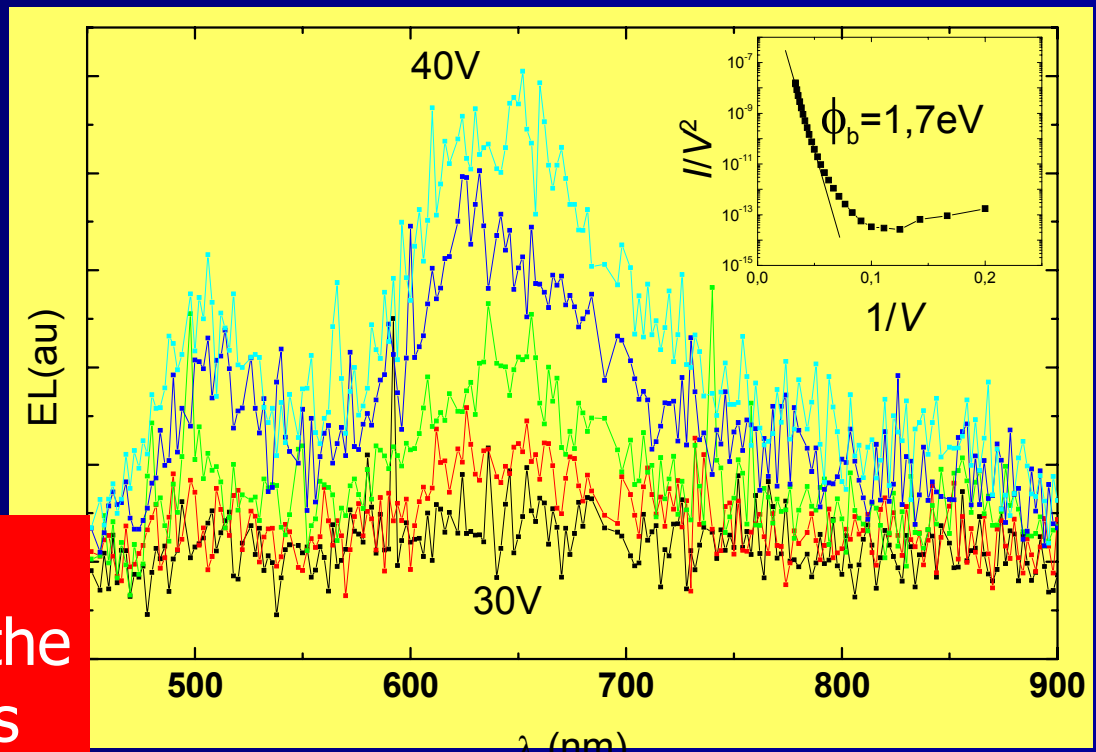
MOS capacitor characteristics

- A reversible charge and discharge effect is observed.
- A important shift of the flat-band voltage due to a large amount of charge stored in the sample



PL characterization

- Broad white electroluminescence observed with a threshold voltage of 25V.
- Fowler-Nordheim regime observed at 22V, suggesting a radiative impact-ionisation mechanism



Electroluminescence from the Si-nc and the C-related aggregates

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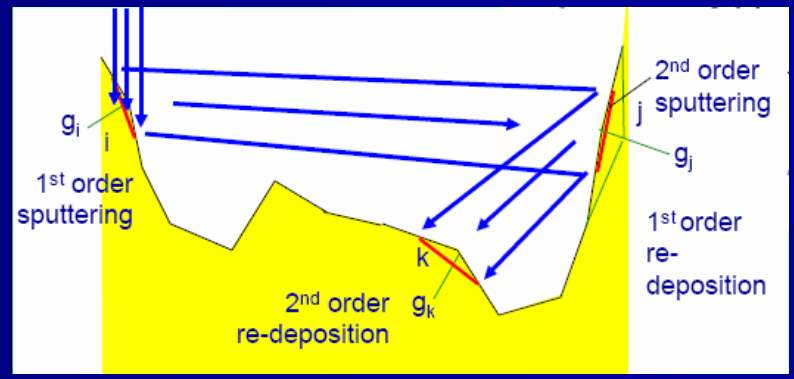
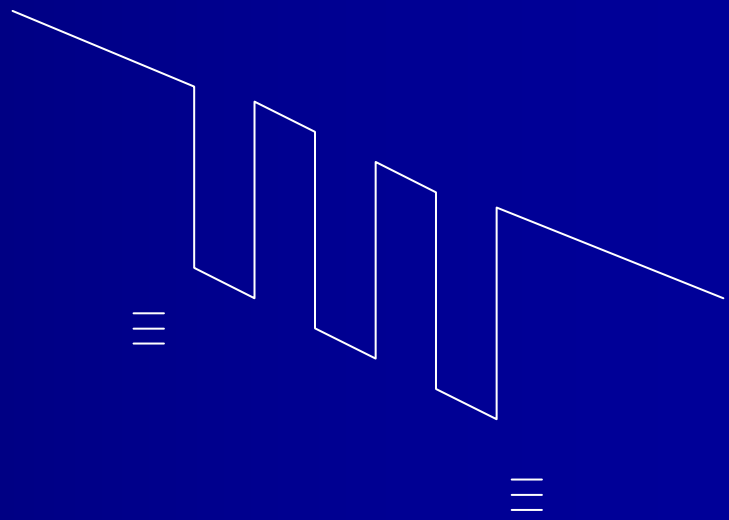
Looking for an explanation

- Redeposition? Not
- Amorphisation? Creation of defects as carrier traps in the 20-30 nm near the cut walls.
- Ga+ doping? Added influence on SiC behaviour, acting as traps.
- C contamination? Could improve dielectric properties
- Further investigation is needed!





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Conclusions

- *A novel way to study transport along a nanocrystal-rich insulating layer has been attempted by FIB technique.*
- *Electrical conduction results underline the role of SiC species on the carrier transport.*
- *Electroluminescence of the Si and SiC has been detected, a very promising achievement in view of optoelectronic applications.*
- *Longitudinal charge retention has been proved, but causes have not yet been determined.*

Acknowledgements

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Thank you for your attention !!