Writing the identity in RFID tags with focused ion beam implantation of transistor gates

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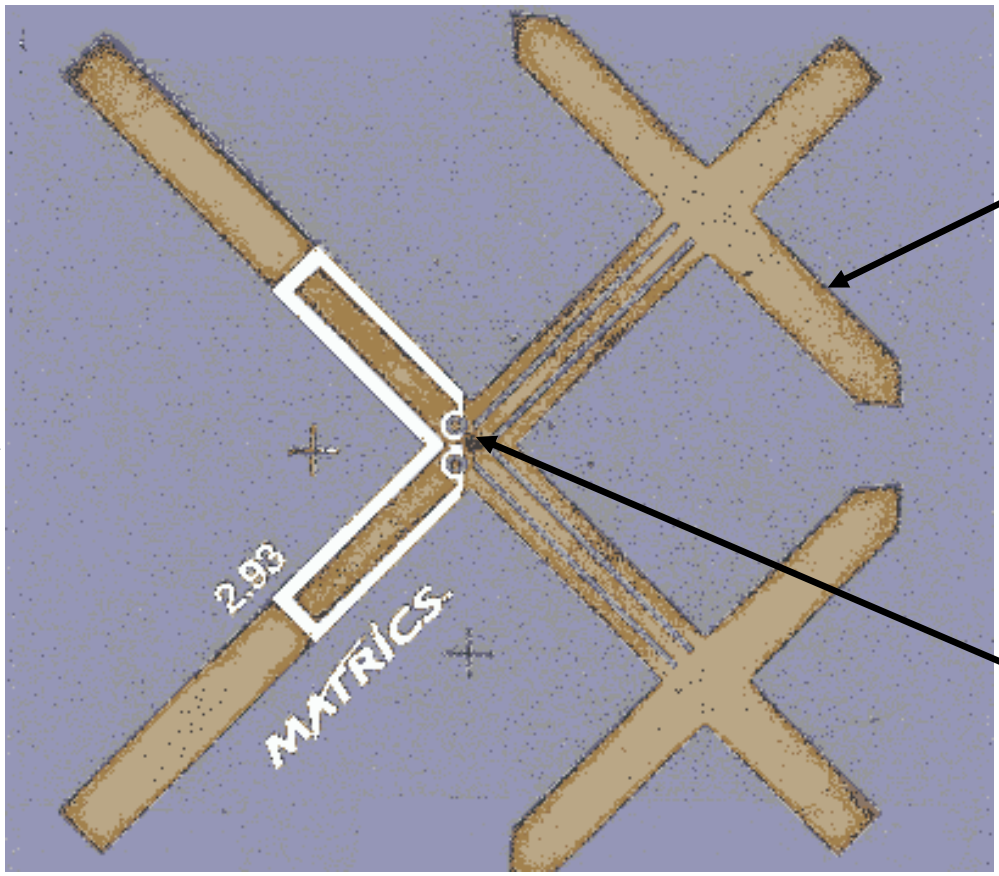
RFID Tag (~10cmx10cm)



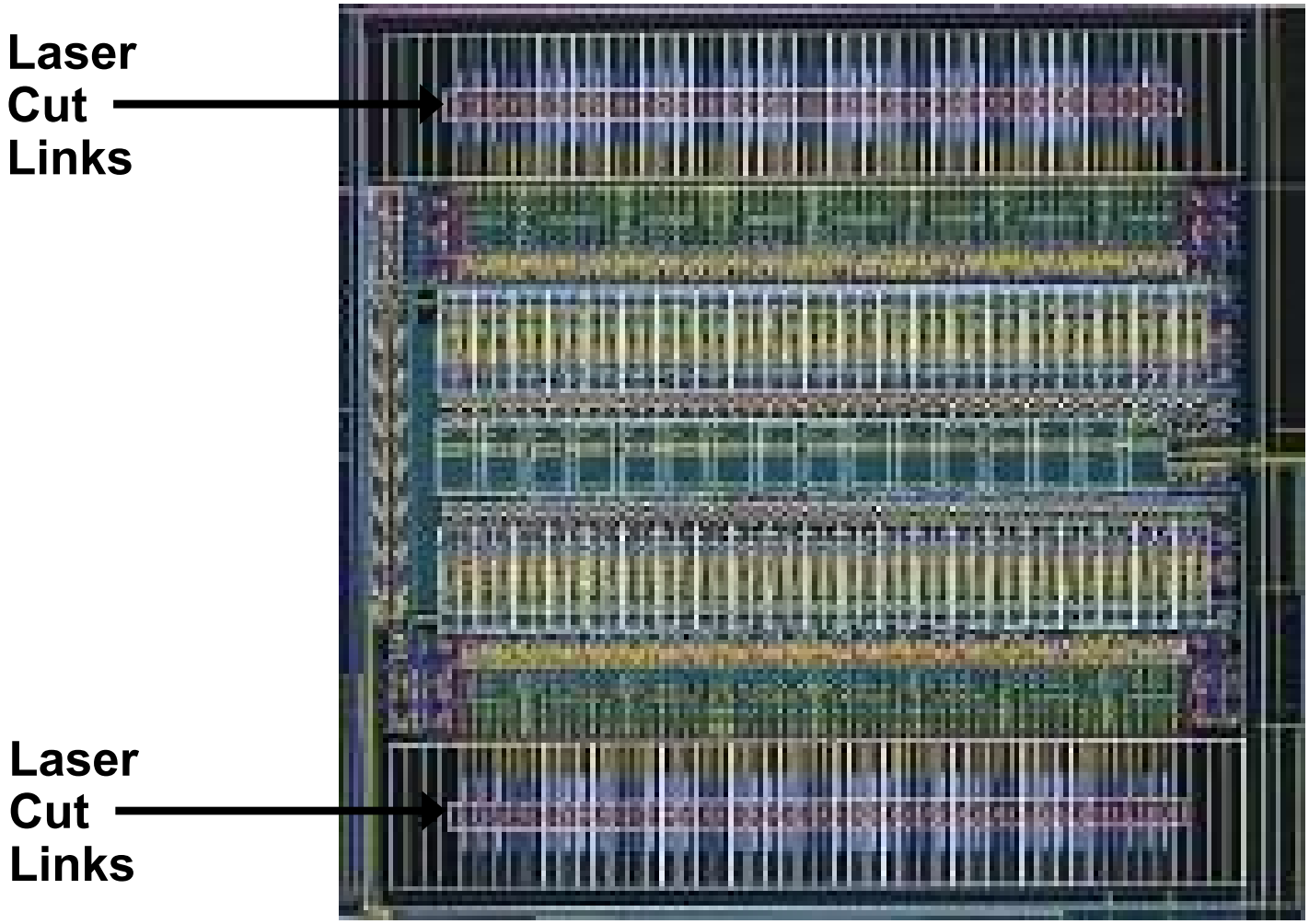
antenna

plastic film

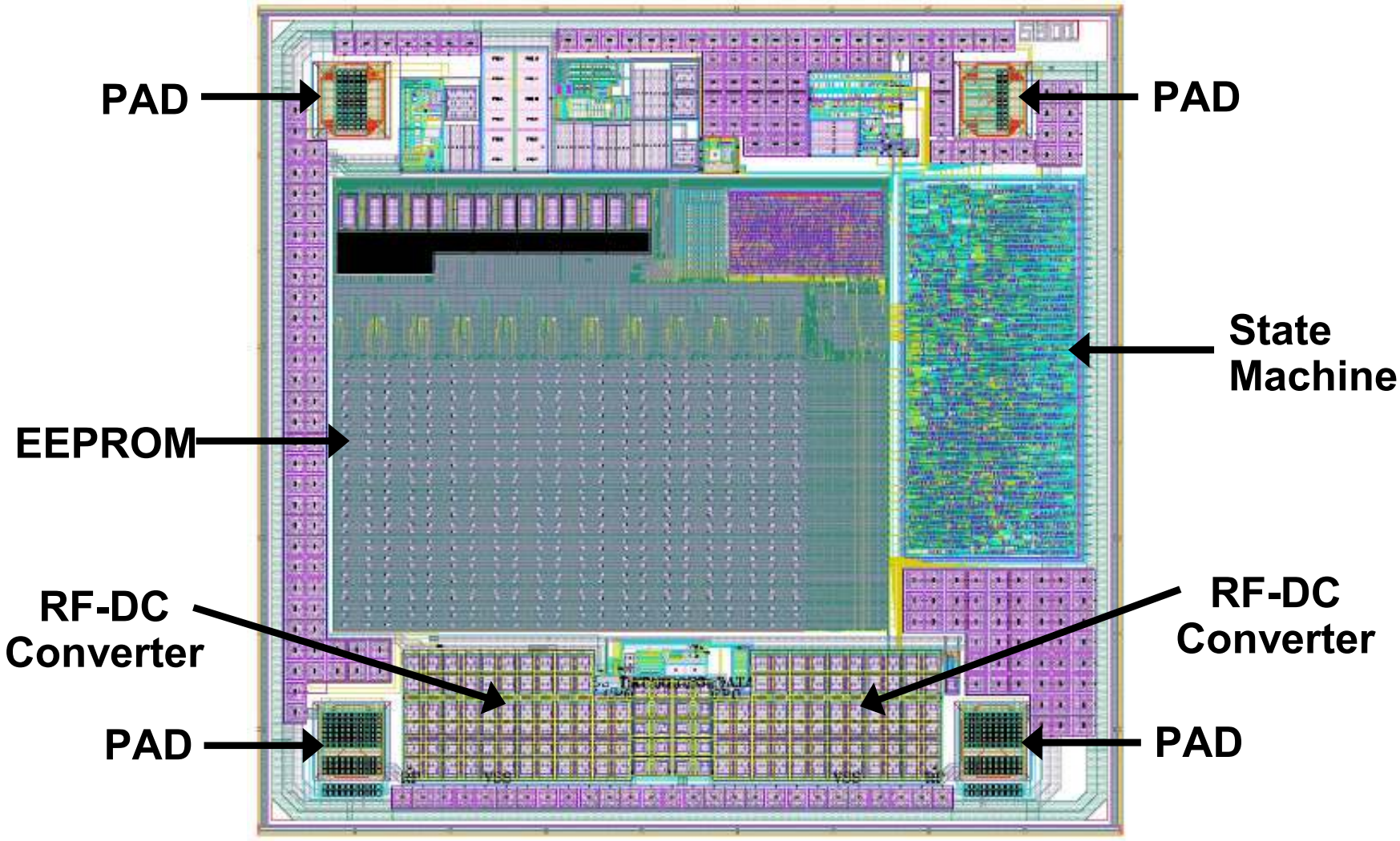
Si chip, no battery
(~0.8mm x 0.8mm)

symbol
The Enterprise Mobility Company™

RFID Tag Pic – ROM memory



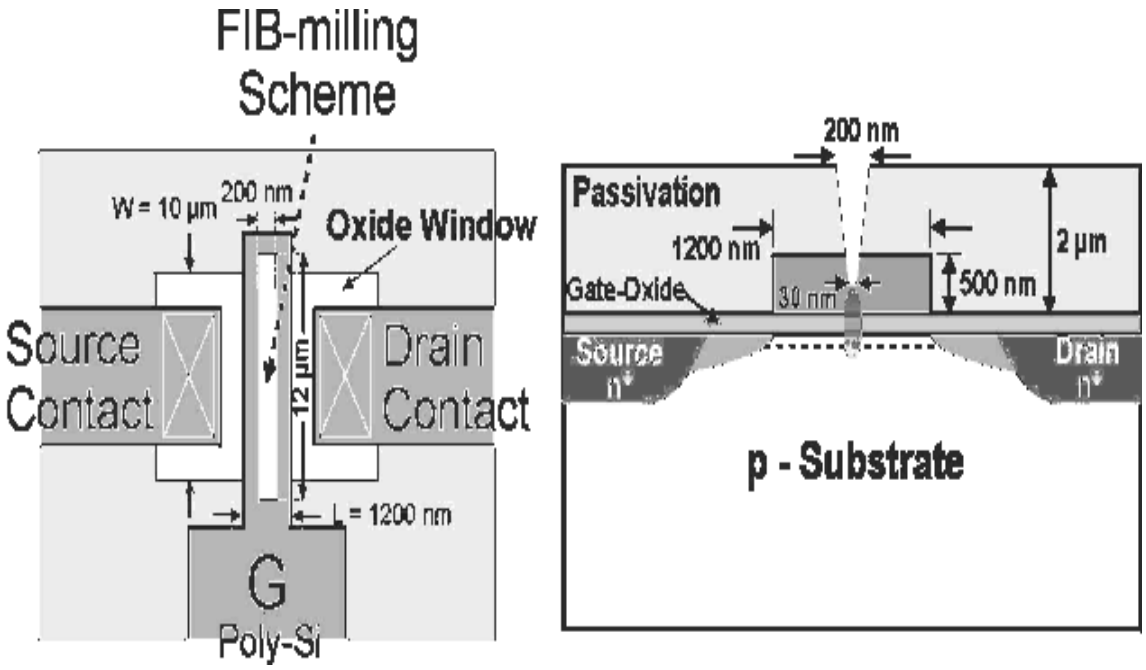
RFID Tag Pic – EEPROM memory



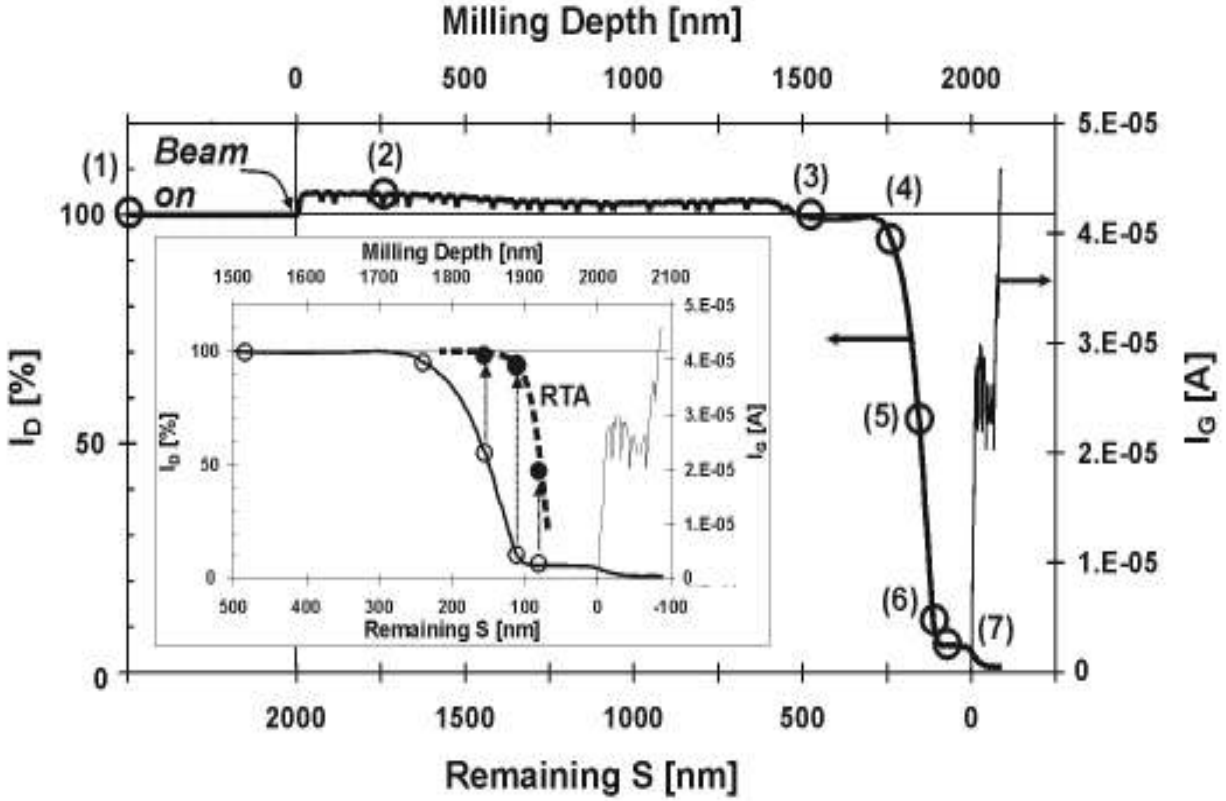
"What is the solution to this problem of security with RFID? The most fundamentally secure solution is simply to store a random number in a read-only memory as the tag ID.
A 112-bit random number can provide more than 10^{33} different numbers, more than enough to ensure uniqueness of the tag ID."

From the *Conclusions* section of book chapter:

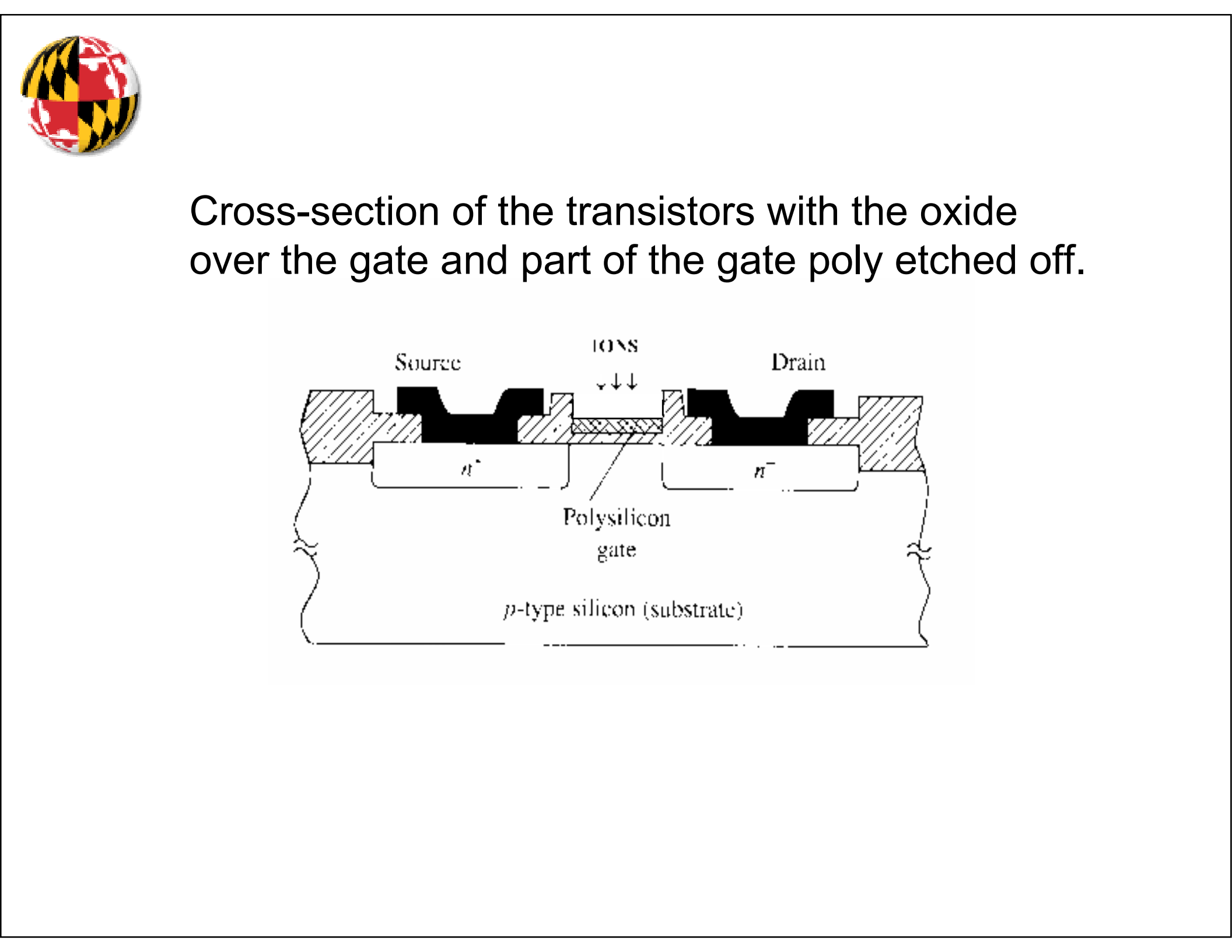
M. R. Arneson and W.P. Bandy "Randomization: Another Approach to Robust RFID Security" Ch. 22 in "RFID : Applications, Security, and Privacy" Simson Garfinkel & Beth Rosenberg, Editors (Pub. June 8, 2005)



Impact Of Focused Ion Beam Assisted Front End Processing on n-MOSFET Degradation



A. Lugstein, W.Brezna, and E. Bertagnolli . 40th IEEE Int. Reliability Physics Symp.(IRPS)

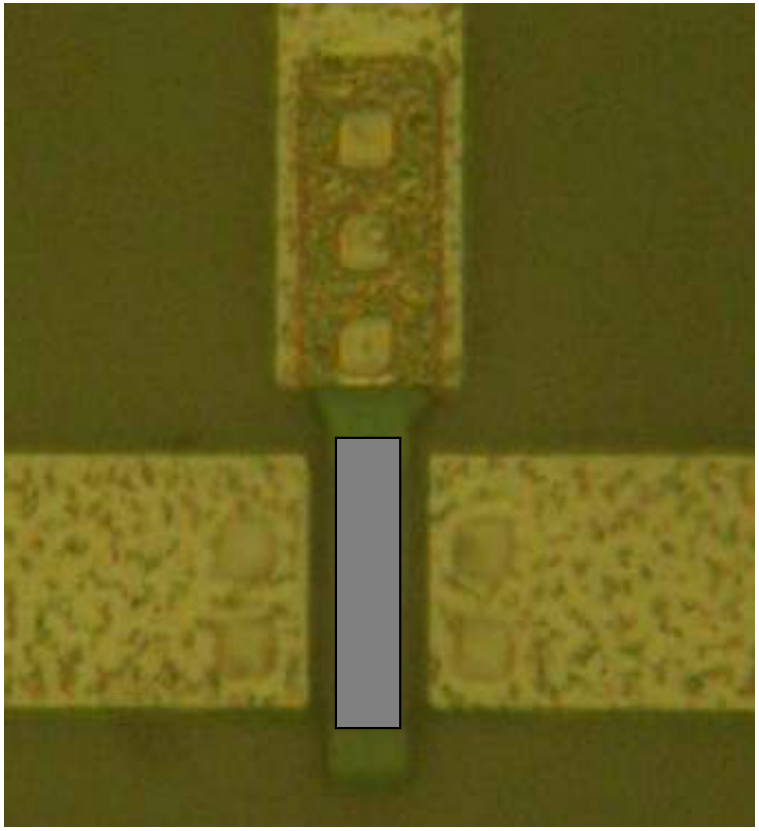


Cross-section of the transistors with the oxide over the gate and part of the gate poly etched off.

Optical micrograph of test transistor on the Berkeley wafer cmos60-#3, showing superimposed in light blue the area where the oxide over the gate is removed.

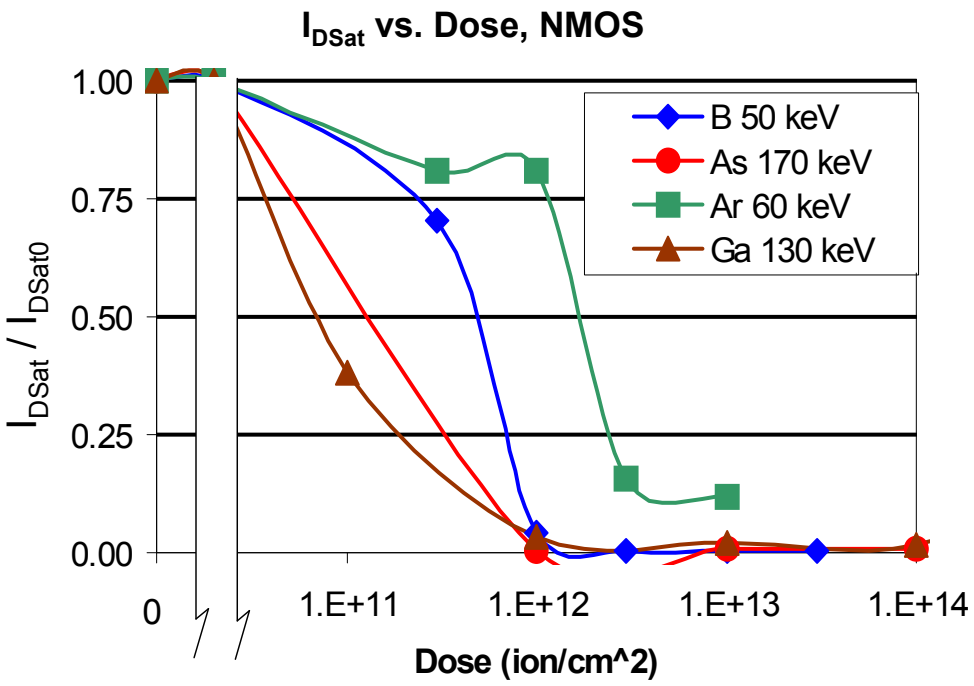
gate

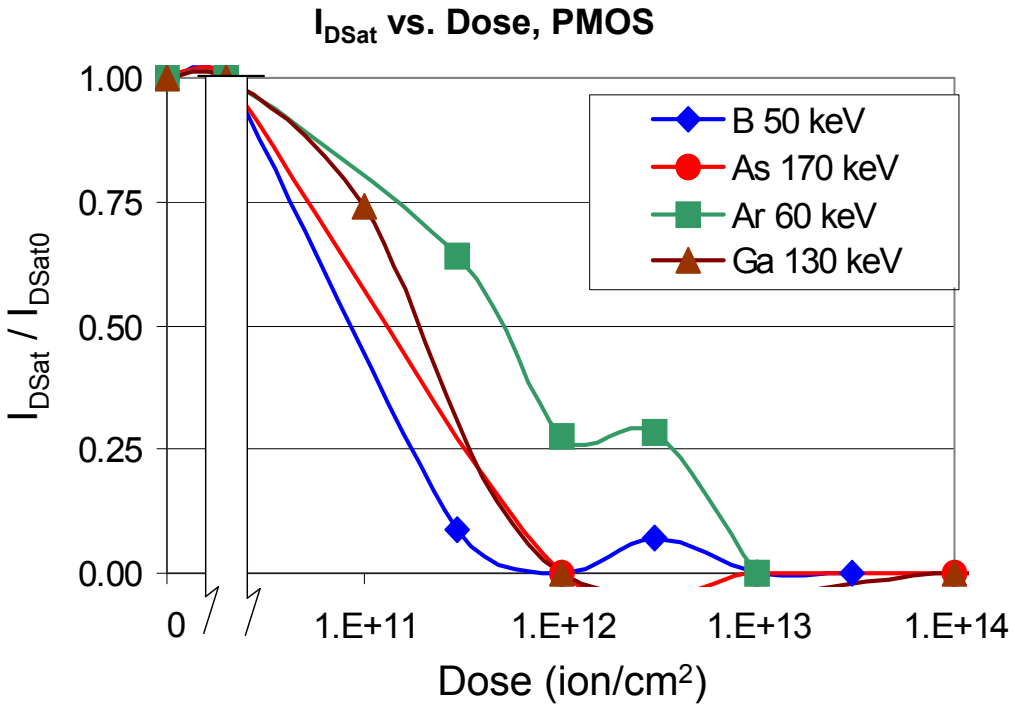
Source or drain



Drain or source

Area from which oxide is etched off. Dimensions and placement not too critical as long as the etched area covers the gate width but not the source or drain.





Source-drain current vs. ion dose at V_T + 2v

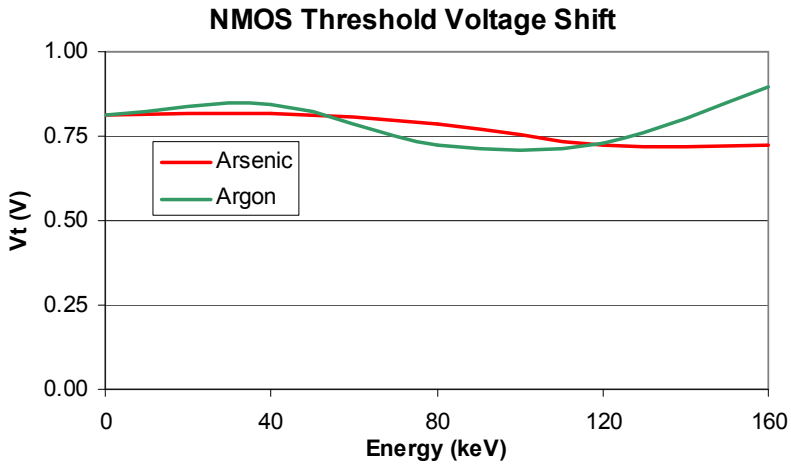
For NMOS and PMOS

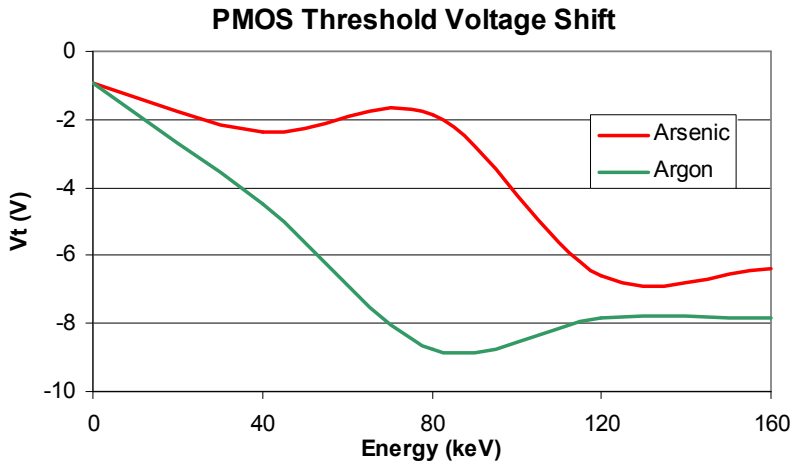
Ranges of the ions used

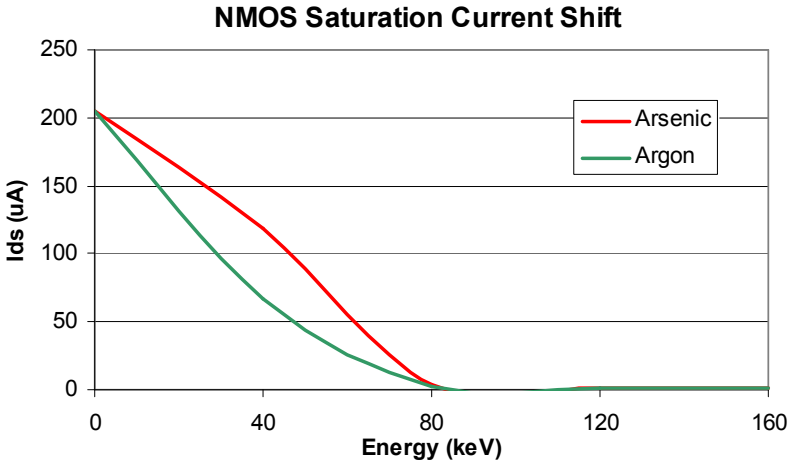
Ion Species	Energy (keV)	Range (nm)	Range Straggle (nm)
B	50	162	57
Ar	60	60	30
Ga	130	81	32
As	170	93	37

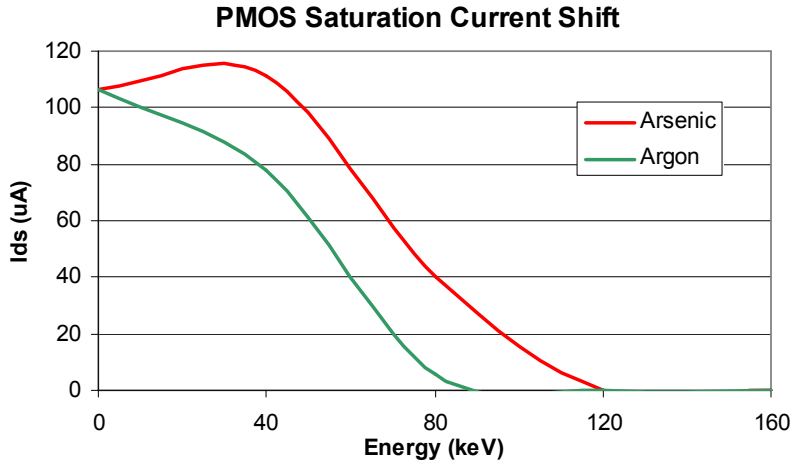
Bernard Smith, *Ion implantation range data for Si and Ge device technologies*
Research Studies Press (1977)

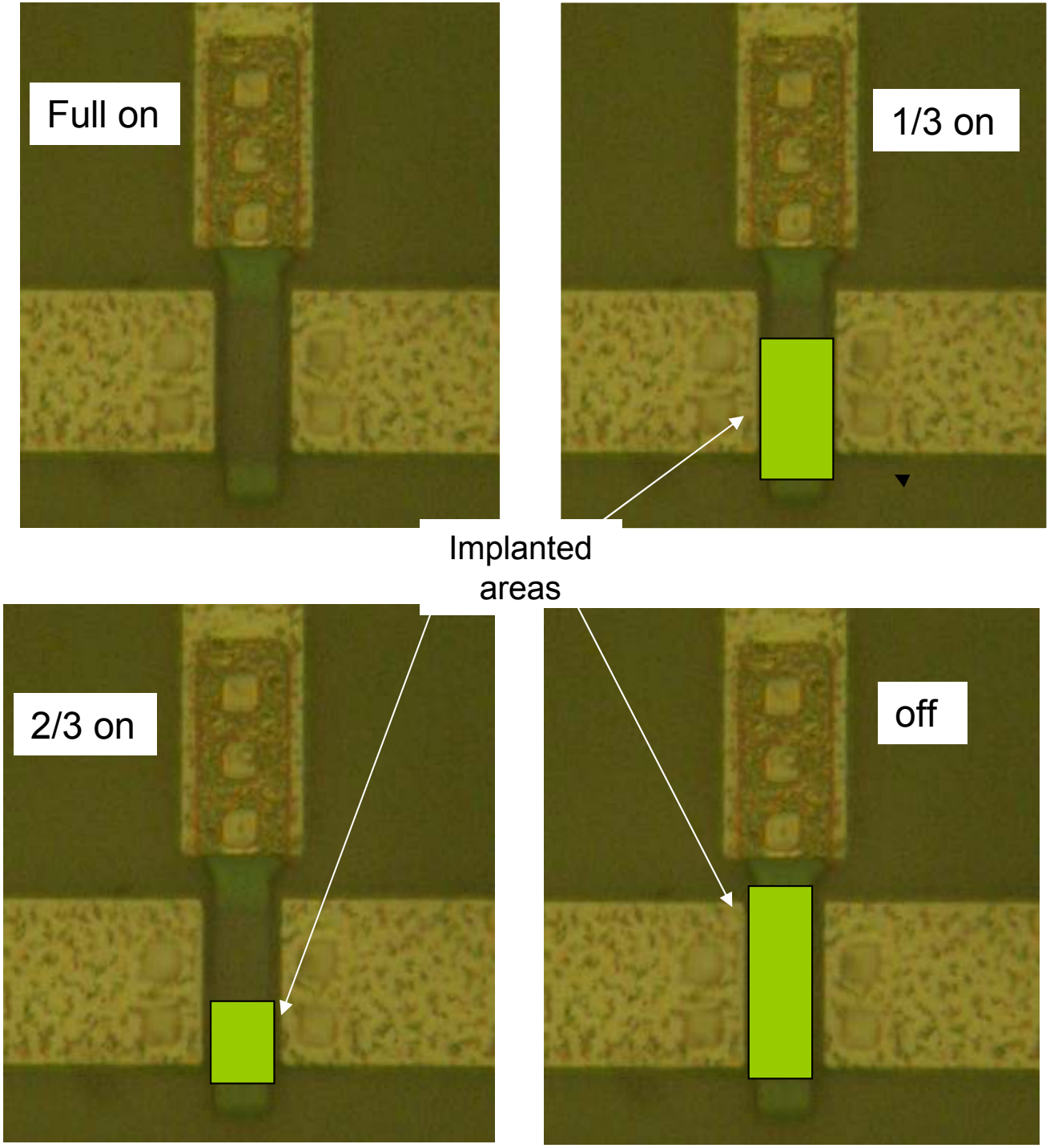
Threshold voltage shift and saturation current shift vs. ion energy at a dose of $10^{12}/cm^2$





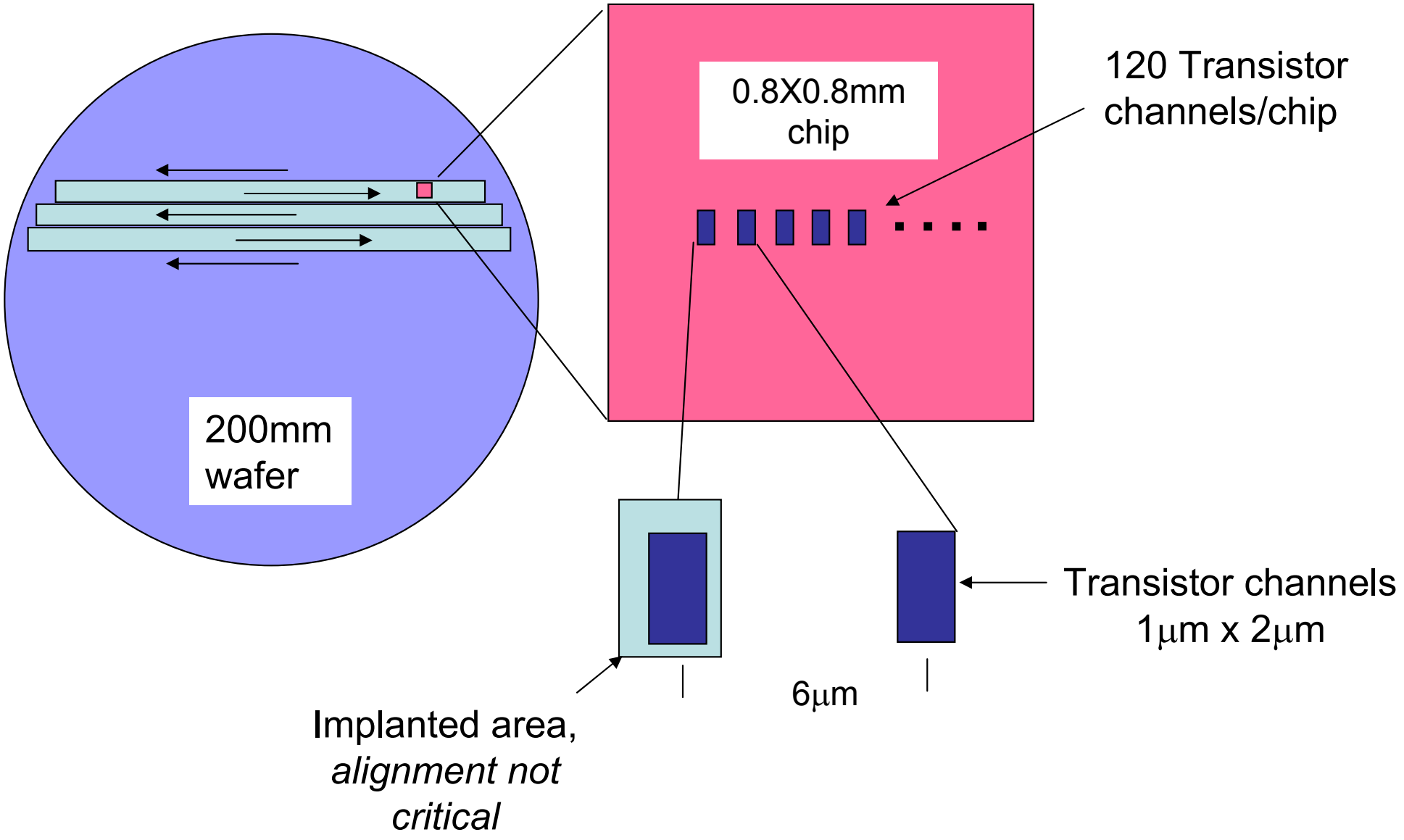






"Bar code with gray scale"

Wafers-per-hour calculation



Wafers-per-hour calculation, (contd.)

3×10^4 chips/200mm wafer

3.6×10^6 transistors/wafer, $3\mu m^2$ ea. area to implant

100pA ion current in beam (~ 6×10^8 ions/sec.)

dose needed = 10^{12} ions/cm^2 or 3×10^4 ions/transistor

or 50μsec/ transistor

or 180 sec.(3 min) beam-on time per wafer

assume write-on-the-fly, double beam-on time to 6min.

stage speed 8cm/sec.

So….10 wafers/hr. at $0.01/chip ❄ **$3000/hr.**

Unresolved issues:

- Ga liquid metal vs. plasma source
- point source vs. aperture projection
- custom RFID chip design
- ion mass / energy / poly thickness trade-offs
- post process vs. in-process
- …and others

Summary

- 10^{12}ions/cm^2 dose of a number of ions will turn

  off transistors used in RFID tags

    (this is a low dose)

- even existing FIB machines, modified to write on

  the fly, can implant 30,000 RFID chips with

    120 sites per chip in 6 minutes.

Acknowledgements

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