HPK EC minies irradiated by protons IV and CV characteristics

Marcela Mikestikova, Zdenek Kotek

Institute of Physics (Prague)

Electrical tests of ATLAS12A Endcap mini sensors in Prague – status

- IV, CV
- Coupling Capacitance
- Rbias: Polysilicon Bias Resistance
- Cint: Interstrip Capacitance
- Rint: Interstrip Resistance
- PTP: Punch-through Protection

10 Unirradiatiated EC sensors

- measurements done,
- all charactersistics tested
- results presented in ATLAS Upgrade Week: https://indico.cern.ch/getFile.py/access?contribId=71&sessionId=42&resId=1&materialId=slides&confId=233534

20 Irradiatiated EC sensors

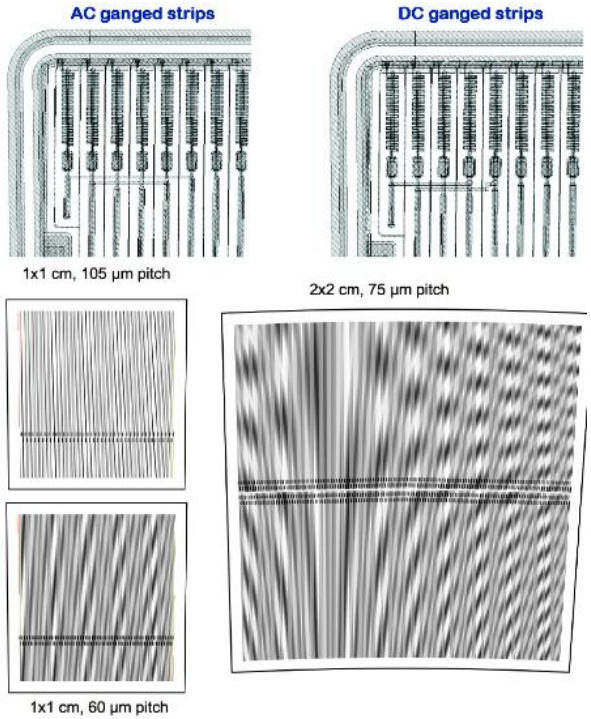
- sensors irradiated in Birmingham by 27 MeV protons up to 3 fluences 5E14, 1E15, 2E15 Neq/cm2
- delivered to Prague in November 2013
- measurements in progress
- up to now only IV and CV tested

Irradiated ATLAS12A EndCap mini sensors in Prague

Irradiation in Birmingham by 27 MeV protons up to 3 fluences 5E14, 1E15, 2E15 Neq/cm2

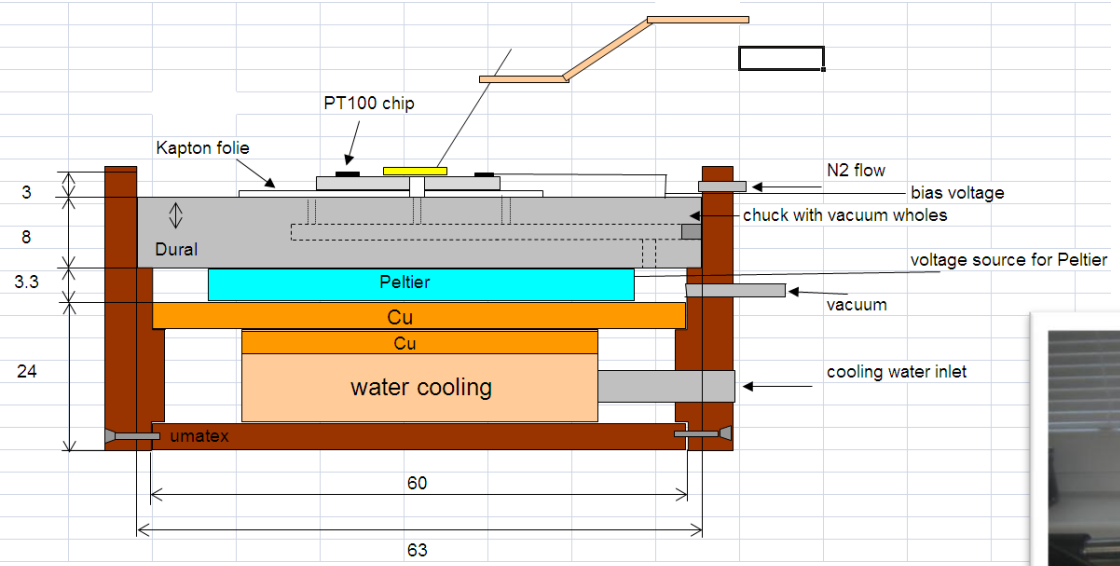
- 20 EC sensors in total (in Prague)
- 12 sensors already tested for IV and CV
- 6 of them measured before controlled annealing
- 9 of them annealed for 80 minutes at 60°C and measured

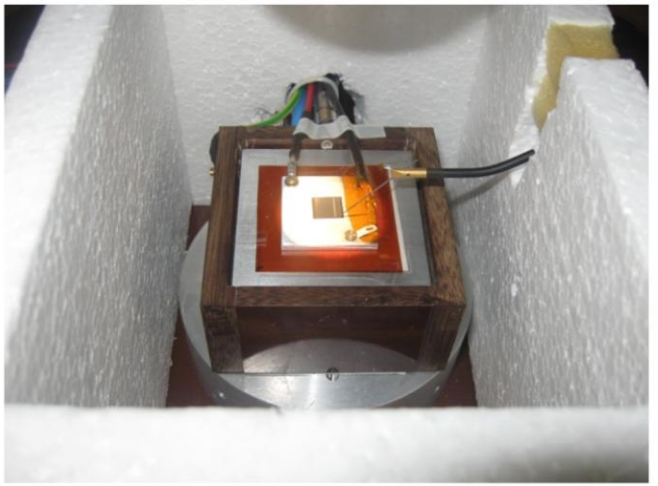
5E14 n_{eq}/cm^2	**1E15** n_{eq}/cm^2	**2E15** n_{eq}/cm^2
✓**W628-EC-Small-C-P7**	✓**W620-EC-Small-C-P7**	✓**W645-EC-Small-E-P8**
✓**W604-EC-Large-C-P9**	✓**W644-EC-Small-E-P8**	✓W605-EC-Large-C-P9
W626-EC-Large-E-P10	W628-EC-Large-E-P10	✓**W644-EC-Small-C-P17**
✓**W639-EC-Small-E-P18**	✓W642-EC-Small-C-P17	✓**W604-EC-Small-E-P18**
✓W645-EC-Large-C-P19	✓**W626-EC-Large-C-P19**	W642-EC-Large-E-P20
W620-Skewed-C-P01 (upper)	W609-EC-Large-E-P20	
W644-Skewed-E-P02 (lower)	W645-Skewed-E-P02 (lower)	W630-Skewed-C-P01 (upper)

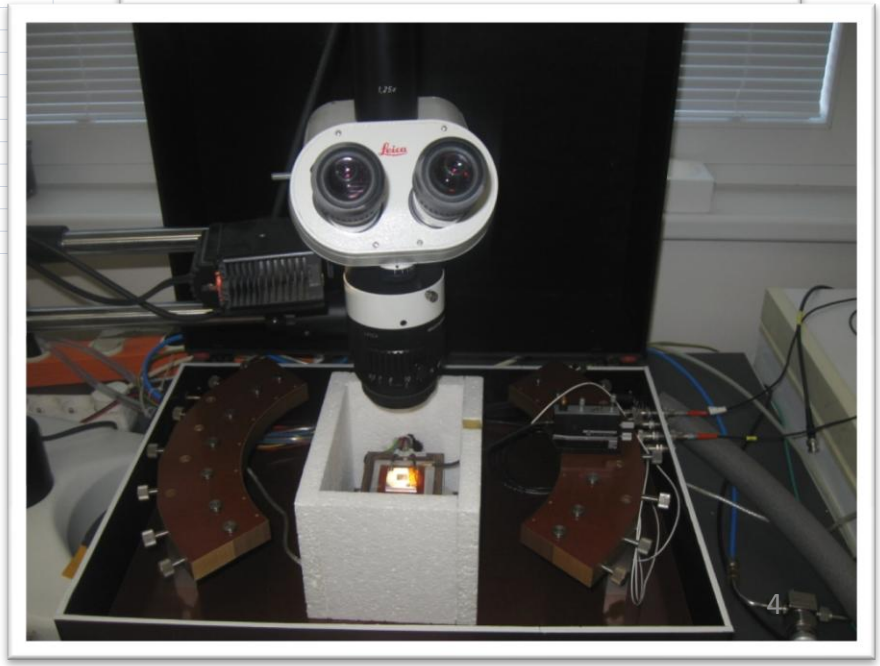


SETUP

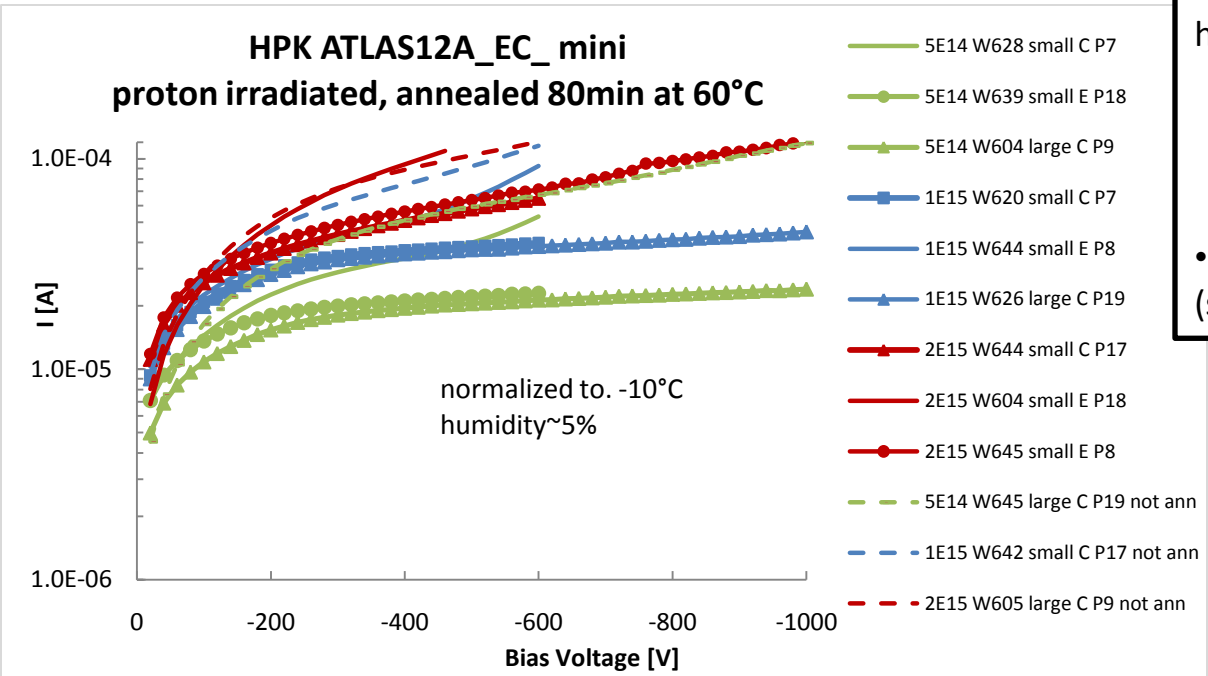
- Proton Irradiated EC minies measured before and after annealing 80 minutes at 60°C
- Chuck cooled by Peltier module to -10°C
- Temperature measured by PT100 connected to chuck
- Nitrogen flow in probestation, humidity < 5%
- Nitrogen precooled down in freezer to avoid warming up sensor

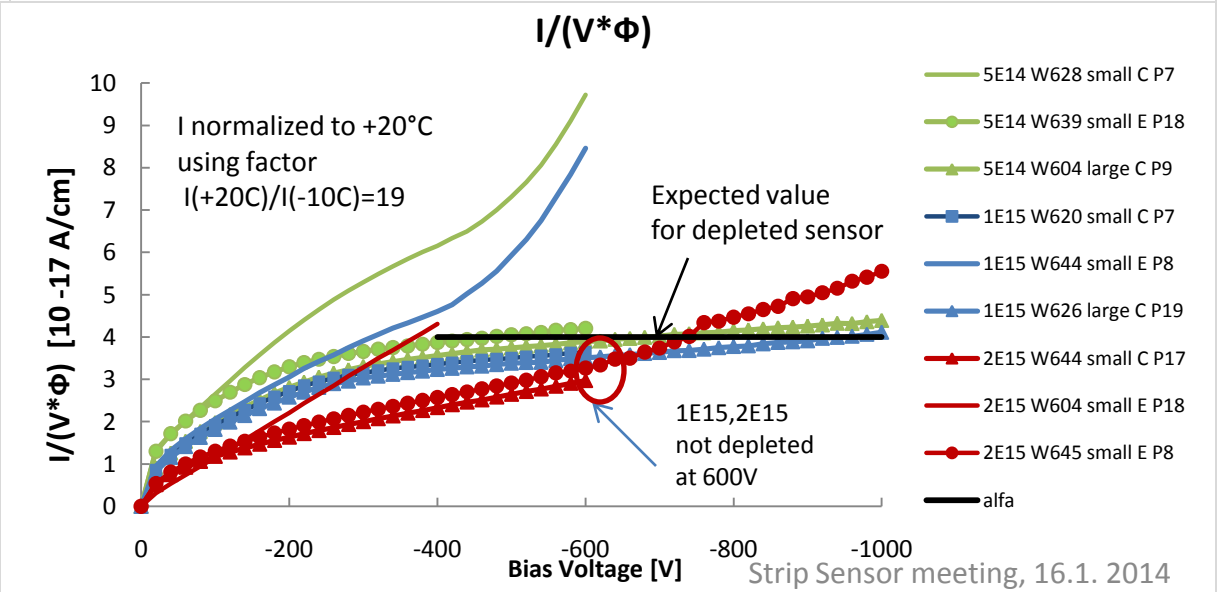






Leakage Current





- only 6 sensors from 12 sensor measured have "good" IV behavior up to 600V/1000V
  - "good": line with marker in the plot
  - "bad": just line, no marker
  - "bad" not annealed: dashed line

- Some of the "bads" have visible defects (see backup)

Leakage current per 1cm² at -10°C at 600V (average for each fluence)

Fluence [neq/cm2]	*I / A [μA/cm²]*	
	„Good"	*„Bad"*
Not irradiated at RT	**0.004**	
5E14	**32.2**	**88**
1E15	**56.8**	**151**
2E15	**99.2**	**>> 160**

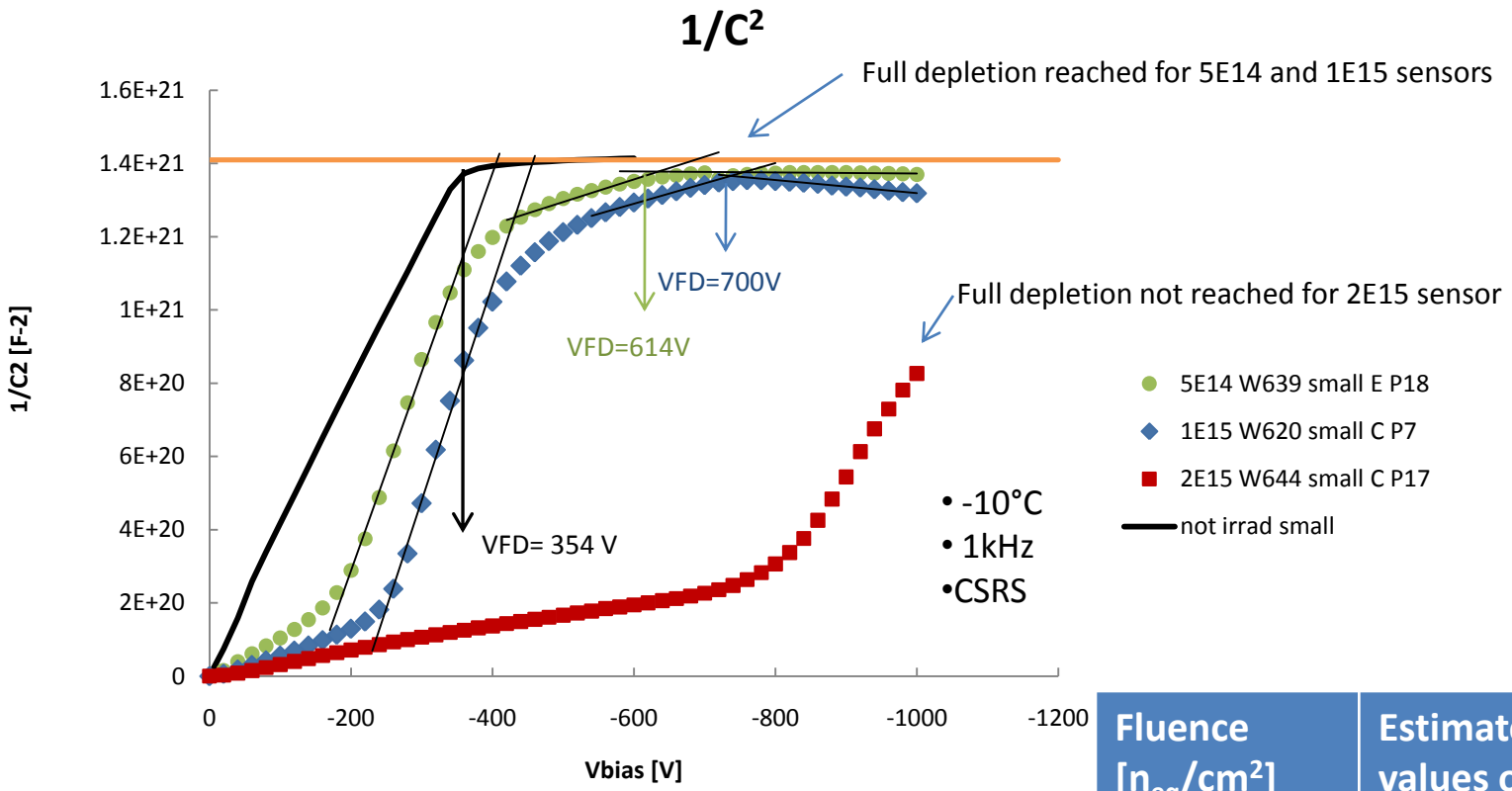
Damage parameter

$$\alpha = \frac{\Delta I}{V \cdot \Phi_{eq}}$$

Alfa = $(3.99 \pm 0.03)10^{-17}$ A/cm
at 80min at 60°C for I at 20°C
[M. Moll]

Active thickness: 302um
Active area:
Large: 0.690 cm2
Small: 0.686 cm2

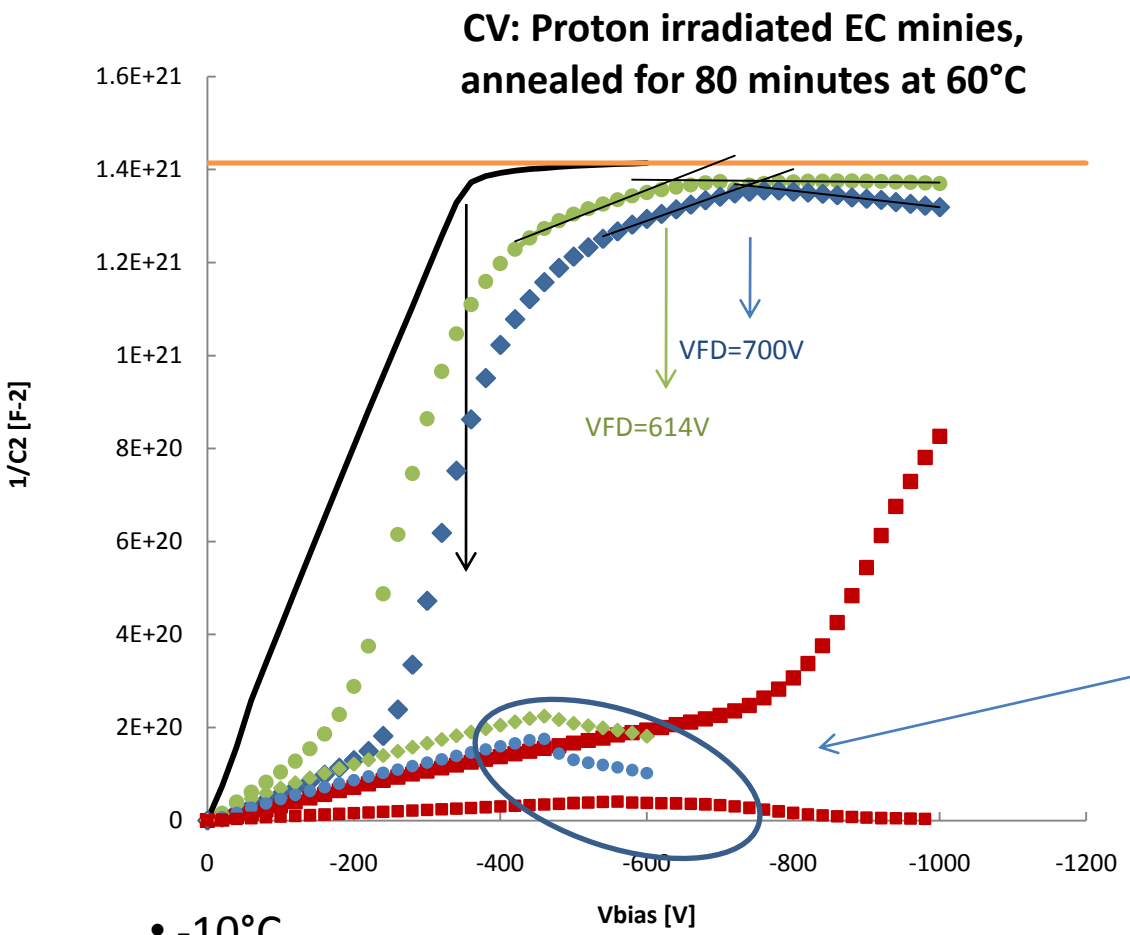
Full Depletion Voltage Determination



- Plot showes CV of "good" sensors only according to IV characteristics
- FDV extracted as crossing of the linear rise 1/C^2 and the saturated value
- For sensors irradiated by 5E14 and 1E15 it's difficult to estimate FDV from CV measurement. It depends on a part of the linear rise which is fitted.
- For 2E15 sensors of 300um thickness it is impossible

Fluence [n_{eq}/cm^2]	Estimated values of V_{fd}	
Not irradiated	354 V	
5E14	614 V	360 V
1E15	700 V	440V
2E15	> 1000 V	> 1000V

CV characteristics



- -10°C
- 1kHz
- CSRS

The plot includes also CV of "bad" sensors with high leakage current

- 5E14 W639 small E P18
- 1E15 W620 small C P7
- 2E15 W644 C P17

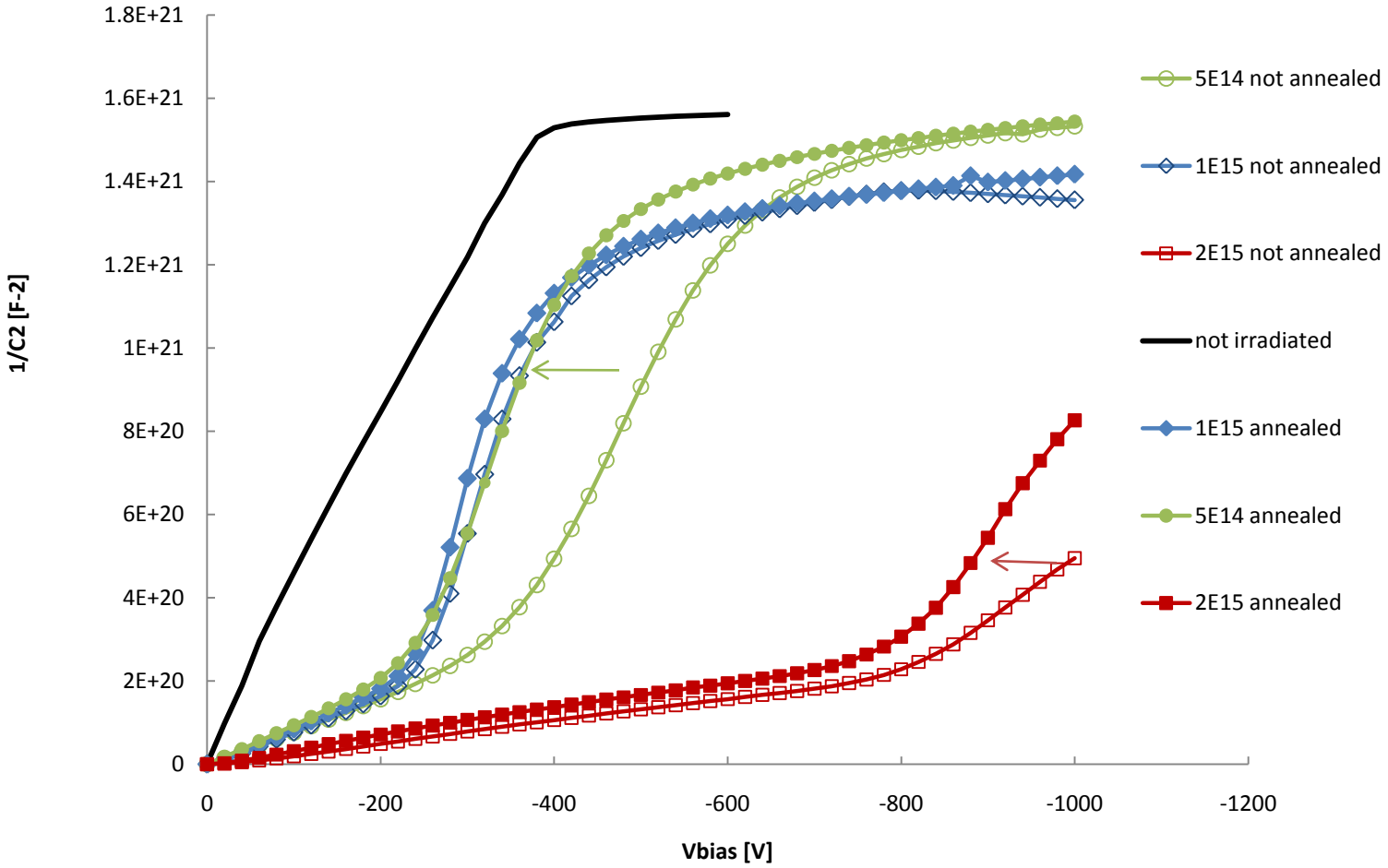
"good"

- not irrad

- 5E14 W628 small C P7
- 1E15 W644 small E P8
- 2E15 W604 small EP8

"bad"

CV before and after annealing 80 minutes at 60° C



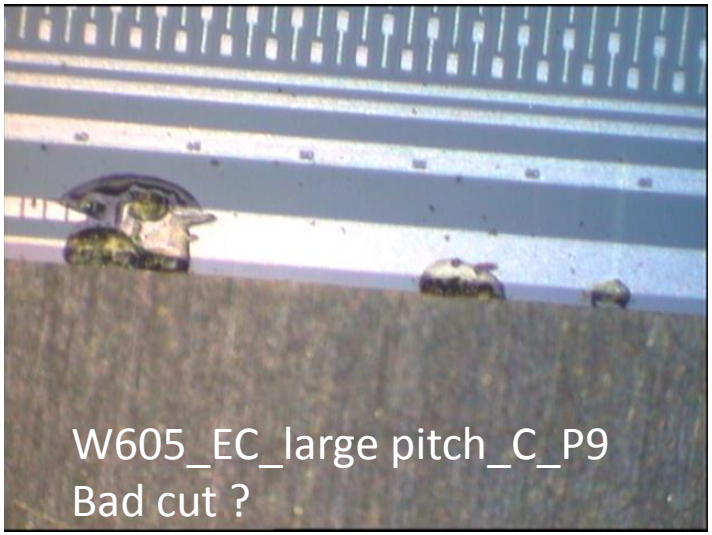
- Annealing shift of CV characteristics is visible on sensors irradiated by 2E15 and 5E14 n_{eq}/cm^2
- sensor irradiated by 1E15 looks like already annealed before controlled annealing

Conclusions

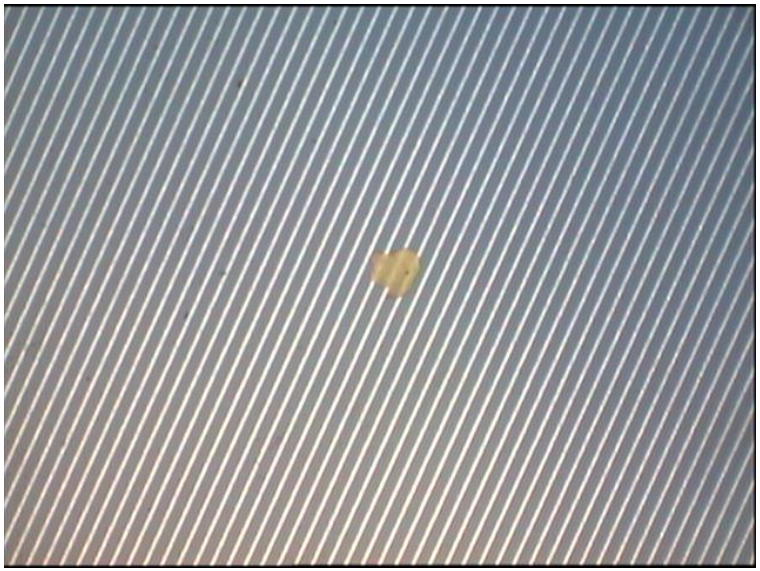
- IV and CV characteristics of ATLAS12A Endcap mini sensors irradiated by protons to 5E14, 1E15 and 2E15 n_{eq}/cm^2 were measured
- Measurements done before controlled annealing and after annealing (80 minutes at 60°C) at -10°C
- only 6 sensors from 12 sensor measured have "good" IV behavior up to 600V/1000V
- The Full depletion voltage estimated from CV is
  610V for 5E14 n_{eq}/cm^2
  700V for 1E15
  >> 1000V for 2E15
- sensor irradiated by 1E15 looks like already annealed before controlled annealing (no annealing shift of CV curve)

BackUp

Defects on irradiated EC minies



W605_EC_large pitch_C_P9
Possibly condensation of humidity?



W642_EC_small pitch_C_P17

Frequence dependence of Bulk capacitance at Vbias> FDV