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First Measurement of Electrical characteristics of ATLAS07 Series I large detectors

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Introduction

Strip detectors in the upgraded ATLAS STC in SLHC will be exposed to anticipated radiation fluence up to $5-9 \times 10^{14} n_{\text{eq}}/\text{cm}^2$ which will substantively change their properties. Until now, changes of the device properties caused by such radiation are mainly studied by irradiation of miniature sensors. Presently, irradiation of real size sensors by protons is being prepared at CERN PS and by neutrons in Prague - Rez.

The aim of the Prague group is

- development of methodic for irradiation of large sensors ($10 \times 10 \text{ cm}^2$) and whole modules under bias and with cooling by fast neutrons from cyclotron neutron generator in Prague-Rez (reaction of p with D_2O)
- verification of this methodic by comparing its results with results of irradiated mini's in Ljubljana
- comparison of irradiation results achieved in Prague and CERN PS
- additional irradiation of sensors at CERN PS to get mixed irradiation

more about neutron facilities in Prague in Peter's talk

Full Size Silicon Micro-strip Sensors

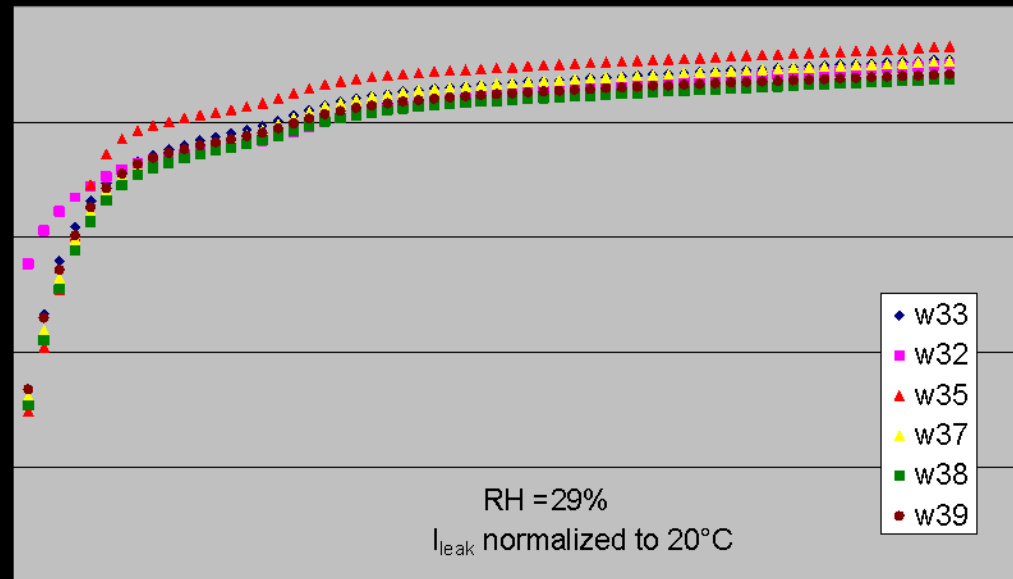
6 full size HPK ATLAS07-Series I sensors were delivered to Prague second week of May09

- *n-on-p* (FZ)
 - AC-coupled readout
 - *n*-strips biased through polysilicon resistors
 - with “p-stop” isolation ($4 \cdot 10^{12}$ ions/cm²)
 - 4 segments: 2 x straight, 2 x stereo angle
 - pitch 74.5 μ m, 1280 strips
 - size: 10cm x 10 cm, 320 μ m
-
- 2500 *p-on-n* sensors for SCT ATLAS were evaluated at Prague Si-laboratory in 2001-2002
- In last 14 days
- we prepared new setup for evaluation *n-on-p* sensors with Automatic Probe Station PS2S150E made in Karlsruhe
 - we made a modification of the LabView test software to run with negative bias voltage *n-on-p* sensors .
 - until now we used V_{bias} up to -600V and we are preparing setup for IV up to -1000 V to see breakdown voltage

Electrical characteristics – Preliminary results

- IV, CV characteristics up to 600 V
 - Vdepletion
 - Interstrip Capacitance
 - Coupling Capacitance
 - Polysilicon Bias Resistance
 - Interstrip Resistance
 - Strip integrity
- } in preparation

IV characteristics



IV curve normalized to 20°C

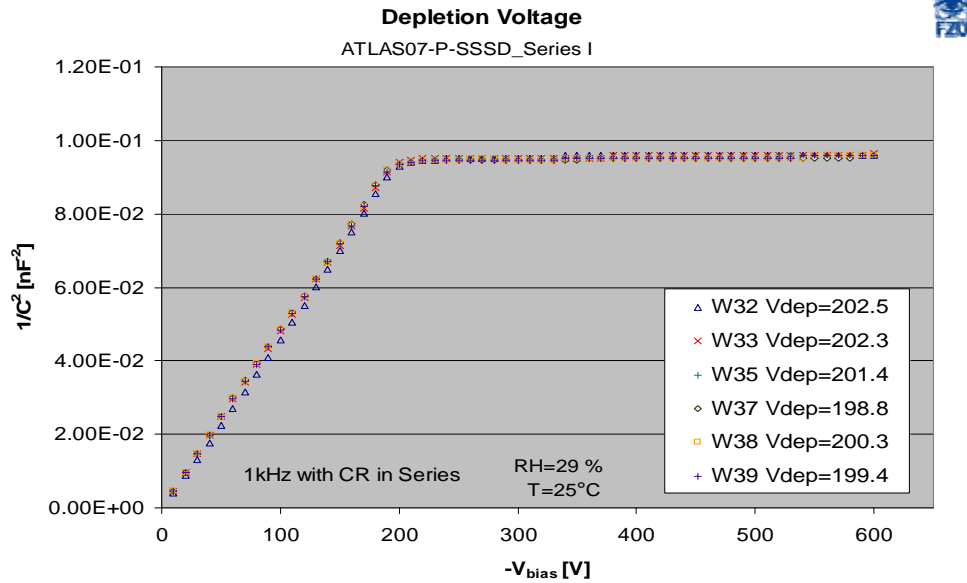
average I_{leak} @ 600 V = 225.1 nA (@20°C)

No breakdown up to 600 V, all 6 sensors very similar

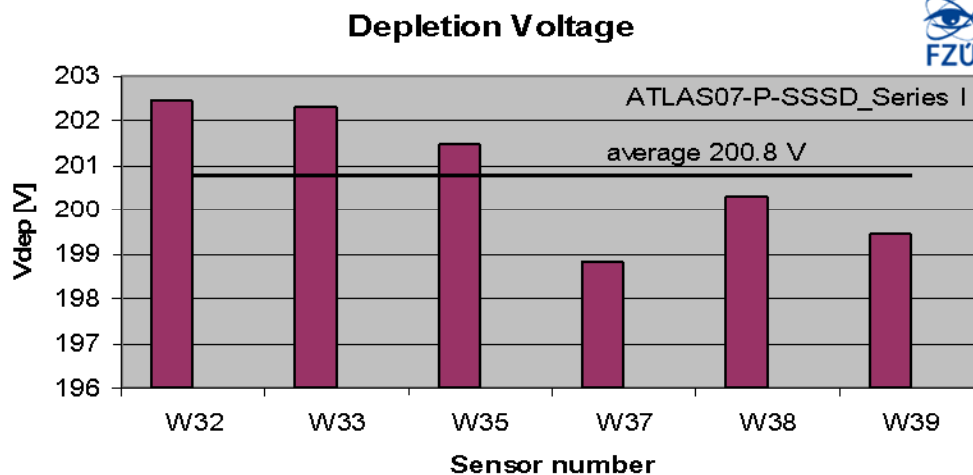
14th RD50 Workshop 03-05 June 2009,

Marcela Mikeščíková

Depletion Voltage



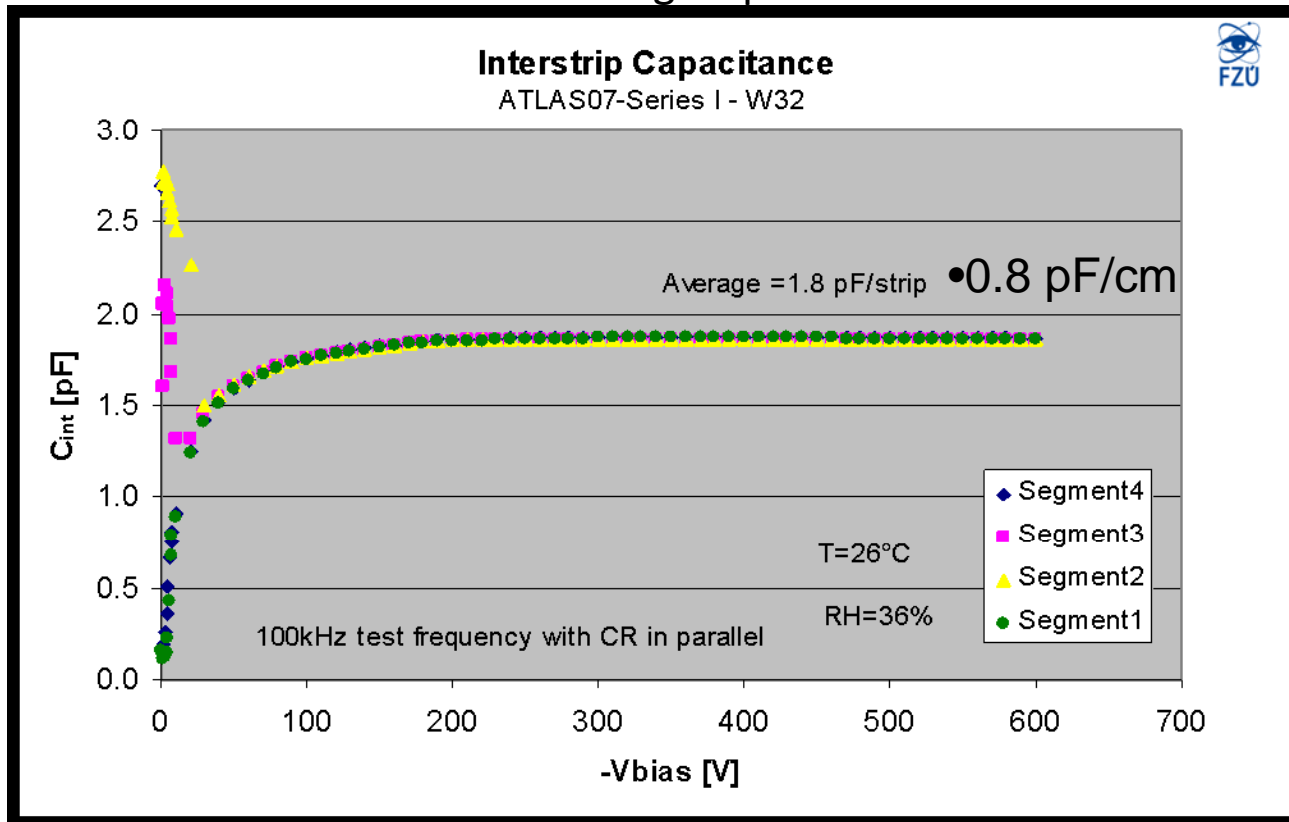
- extracted as crossing of the linear rise and the saturated value
- very smooth behavior



- maximum difference in V_{dep} is 3V

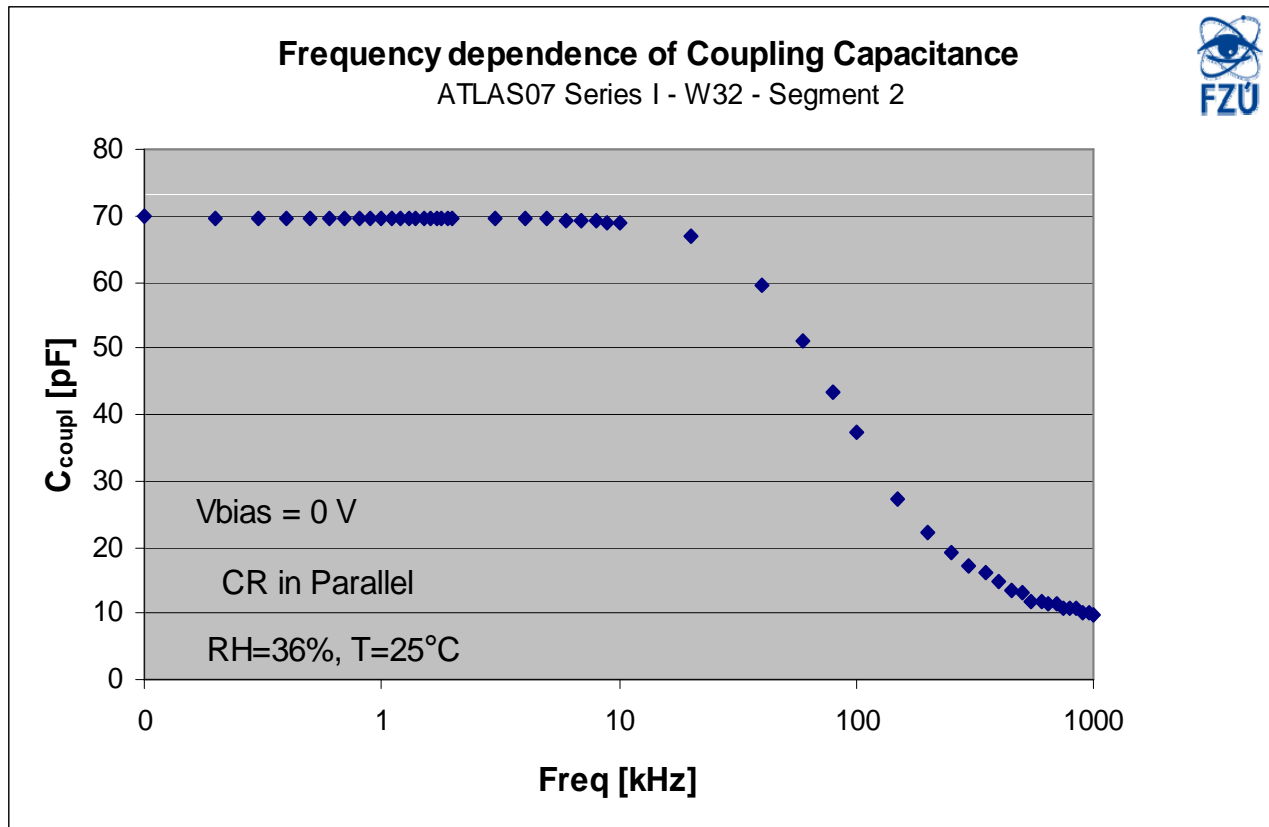
Interstrip Capacitance

- between a central strip and its nearest neighbour on both sides with others floating
- consistent with measurement of other groups

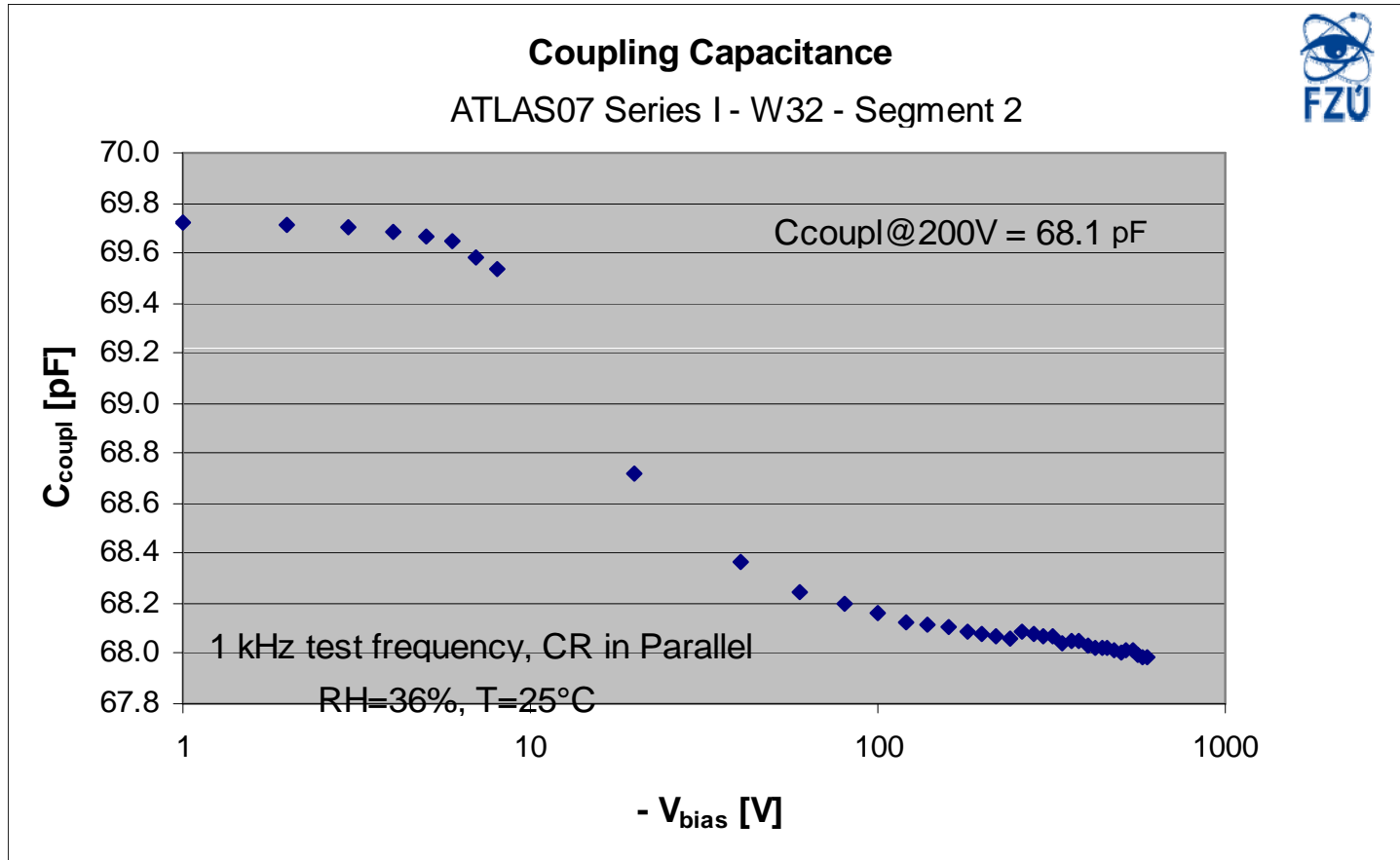


Coupling Capacitance

- between the strip metal and strip implant
- up to 10kHz constant, @ 1kHz middle of plateau



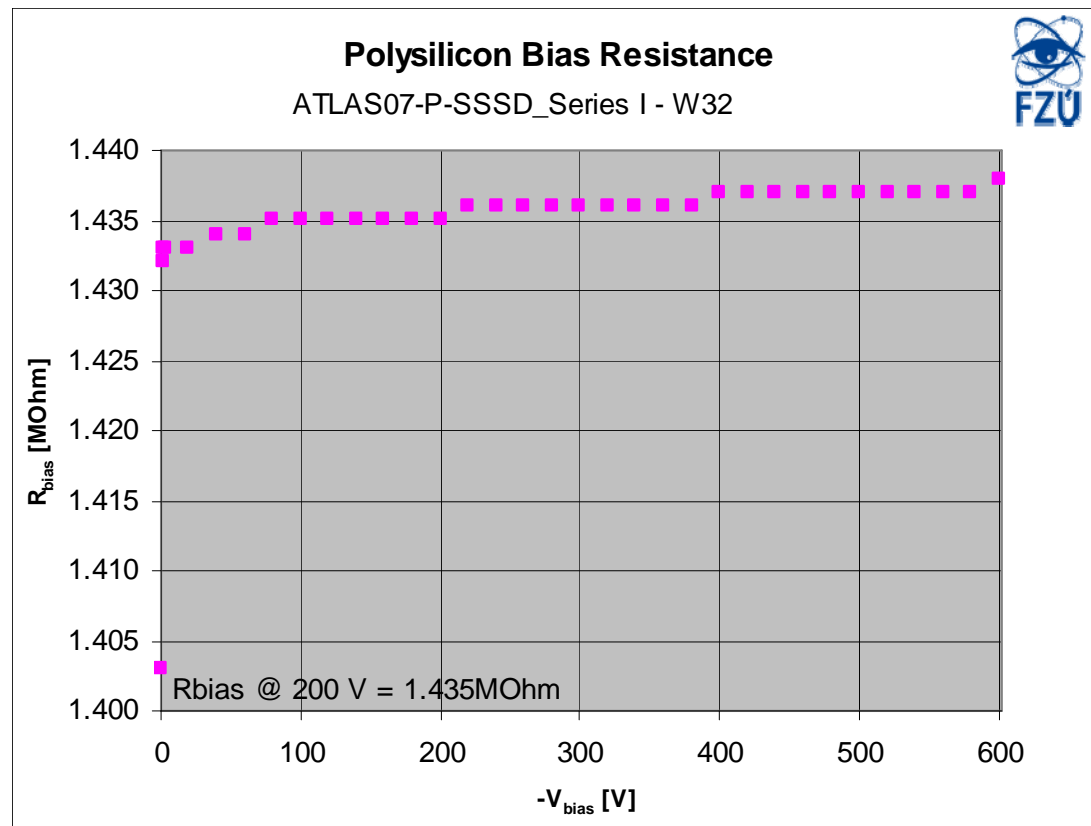
Coupling Capacitance



- changes in level of 2 pF

Polysilicon Bias Resistance

- Voltage 1-6 V was applied to DC pad. IV for applied voltage was measured on bias rail
- $R_{bias} = dV_{appl} / dI$ as a function of bias voltage
- The backplane on V_{BIAS} , bias rail on GRD



Next steps

Next step before irradiation:

- continue with measurements to increase statistics before irradiation
- measure the strip integrity with automatic probe station
- prepare setup for IV up to 1000 V to see breakdown voltage
- measure the effect of the cable lengths for online measurements during irradiation and sensor temperature on electrical characteristics

Irradiation plan:

- irradiation of 4 full size sensors with fast neutrons at Cyclotron U-120M at NPI Rez in Prague at 3 different distances from the target to get different fluences.
- we have estimated that the full size detectors could be irradiated up to integrated fluency $1.3 \cdot 10^{15} n_{eq}/cm^2$ in ≈ 50 hours with non-homogenities $\approx 20\%$
- calibration irradiation run: June 26-28, 2009 to get $\sim 0.5 \cdot 10^{15} n_{eq}/cm^2$
- next run is planned in October 09 giving possibility to irradiate sensors with FE or complete modules (if any) up to $1.3 \cdot 10^{15} n_{eq}/cm^2$

We are preparing irradiation setup

- with cooling (liquid N) up to -25 or -30° C
- with on-line monitoring of IV, CV of all irradiated sensors,
- with on-line measurement of $C_{interstrip}$, R_{bias} , $R_{interstrip}$, C_{coupl} at 3 strips of one sensor during irradiation (contact to 3 adjacent AC pads, 3 adjacent DC pads, bias pad and backplane)

After irradiation:

- perform measurements of sensors at -25° C before and after controlled beneficial annealing to check functionality of full size sensors after irradiation up to fluence in the upgraded SCT in the SLHC
- evaluate irradiated sensors with non-irradiated DAQ

Summary

- we prepared setup for evaluation of large n -on- p sensors (10x10cm)
- we changed LabView test software
- result of measurement of IV, CV, C_{int}, C_{coupl}, R_{bias} are consistent with measurements of others on the same type of sensors
- R_{int} – different methods of measurement are still tested
- strip integrity will be prepared in the next week
- we prepare methodic for irradiation of large sensors (10 x 10 cm²) and whole modules under bias and with cooling by fast neutrons from cyclotron neutron generator in Prague-Rez D₂O(p,xn)