Irradiation tests on standard and oxygenated ROSE diodes produced by ST Microelectronics and Sintef

Michael Moll

- CERN -

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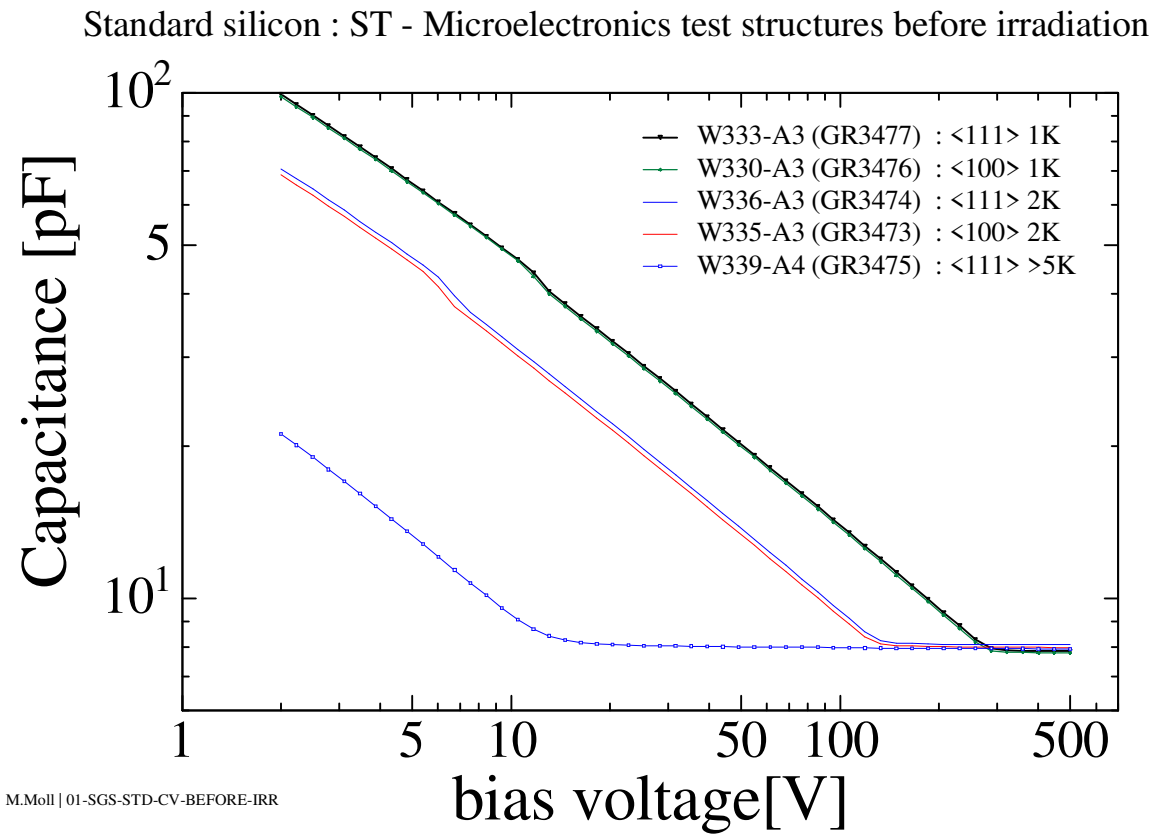
J.Wuestenfeld, …. ROSE

Material / Diodes / Irradiations

- Wacker silicon
- Different orientations: <111> and <100>
- Different resistivities: 1, 2 and 15 KΩcm
- Diode producer: ST Microelectronics - ROSE mask
- Two batches:
  - 1.) No oxygen enrichment ⇒ Standard diodes
  - 2.) Oxygen enrichment ⇒ Oxygenated diodes
    (30h or 60h at 1200ºC)
- Irradiation: CERN PS 24GeV/c protons

ST Microelectronics - standard diodes

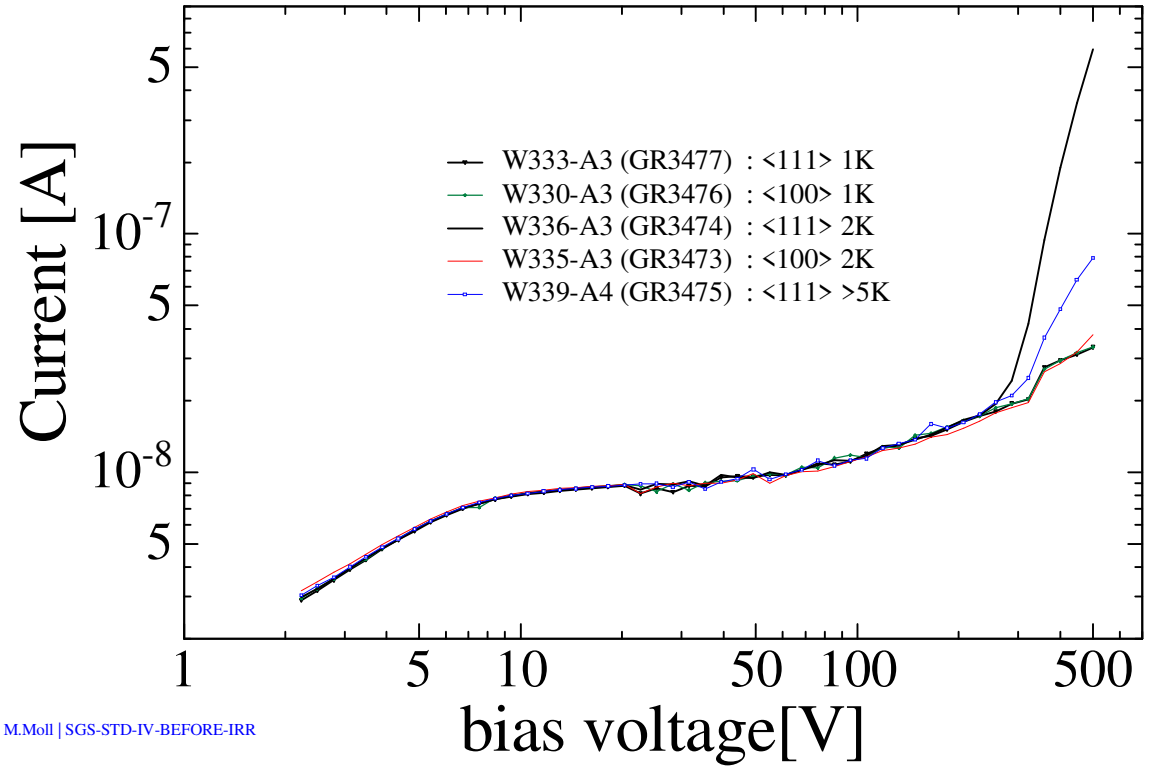
- Different orientations <111> and <100> and resistivities
- CV measurements before irradiation



ST Microelectronics - standard diodes

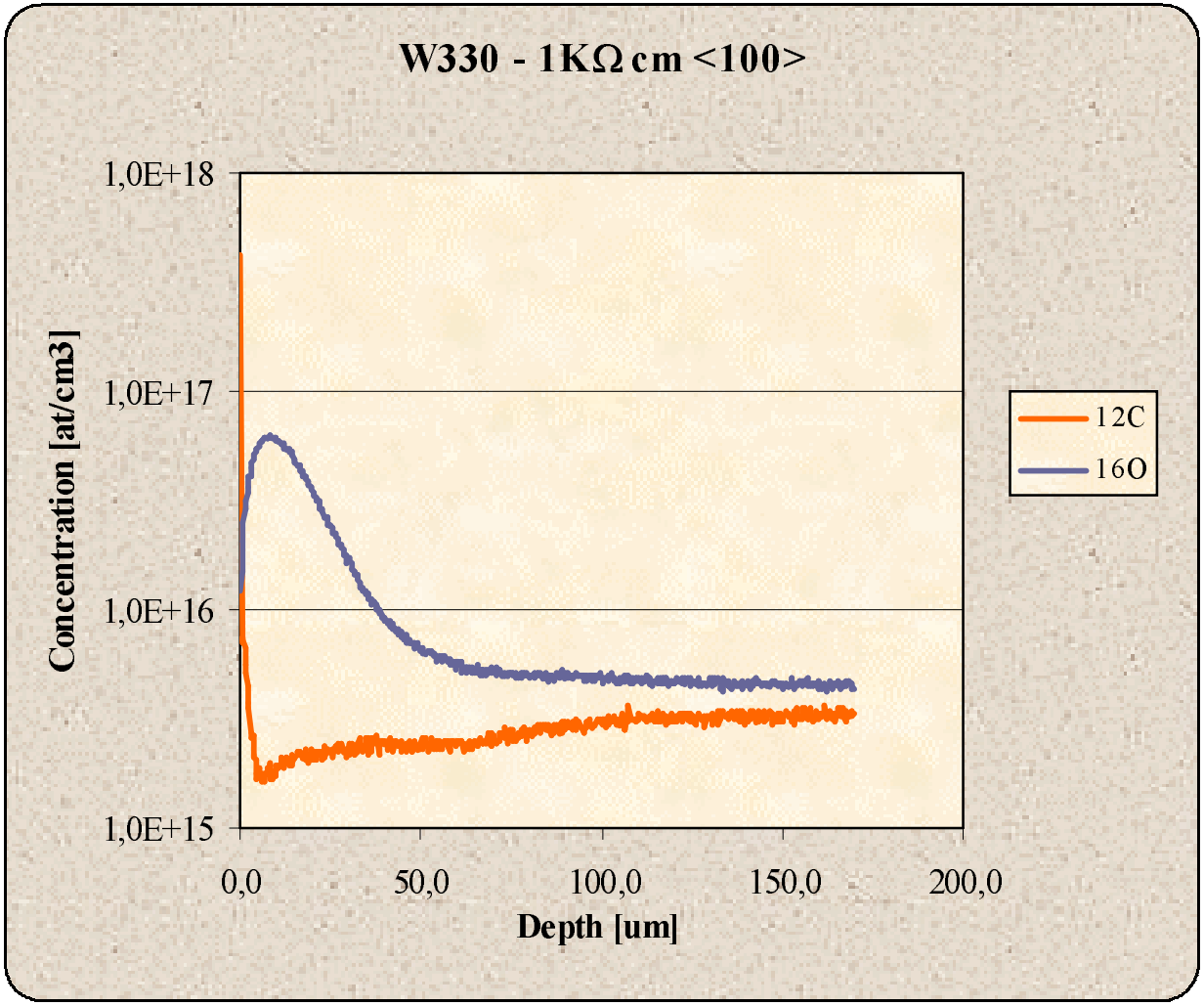
- Different resistivities and crystal orientations
- IV measurements before irradiation

Standard silicon : ST - Microelectronics test structures before irradiation

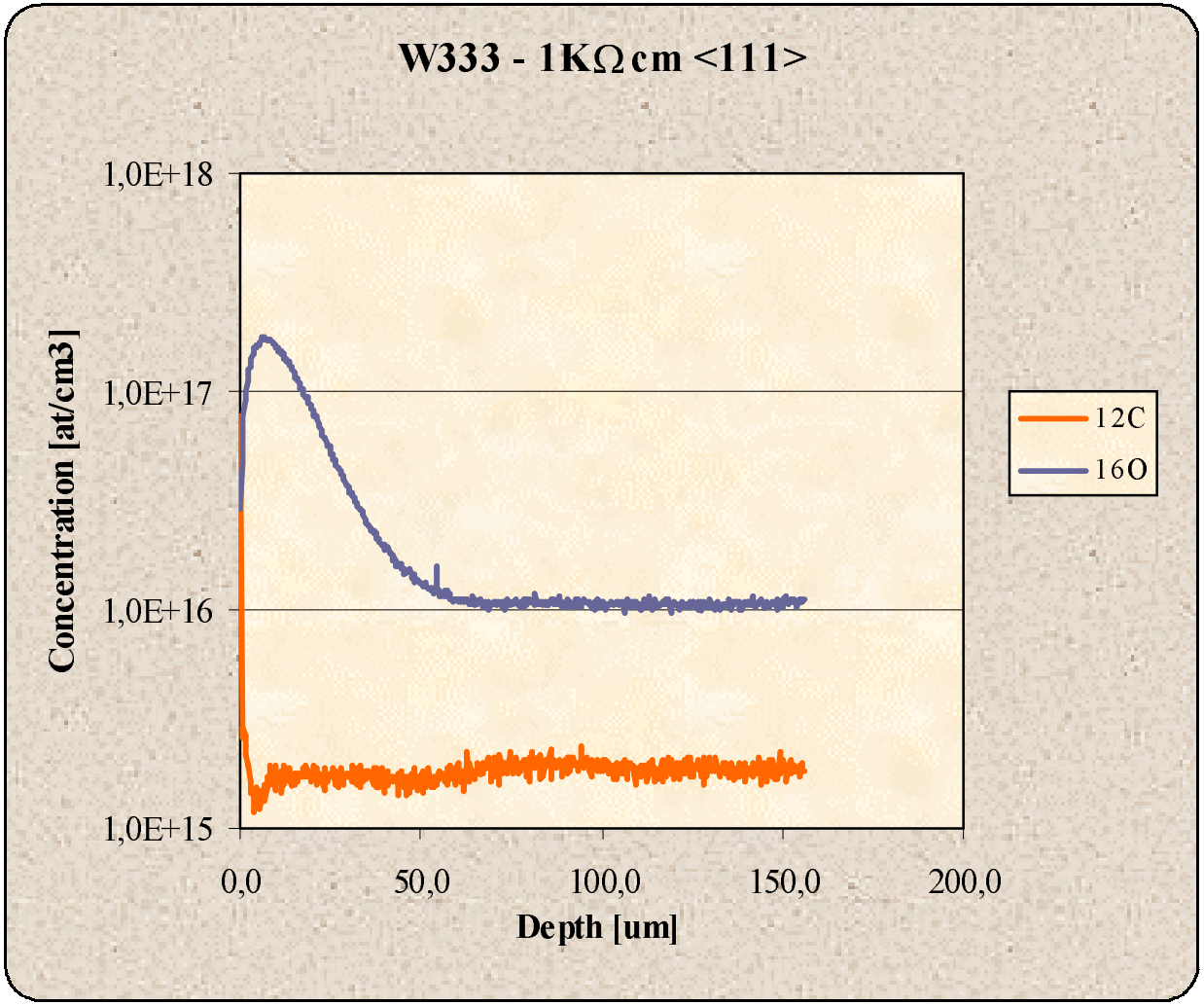


M.Moll | SGS-STD-IV-BEFORE-IRR

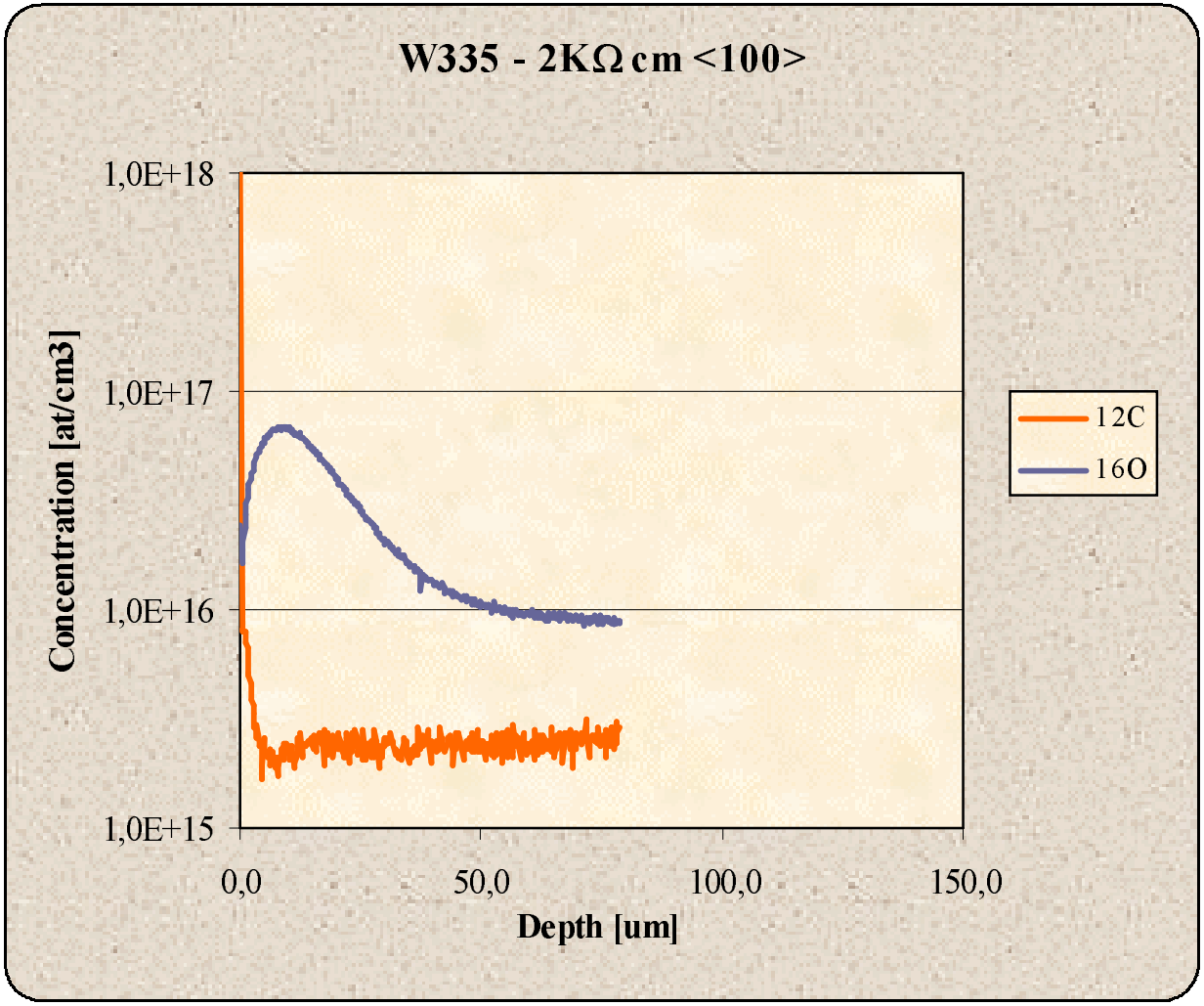
SIMS Measurements - standard samples



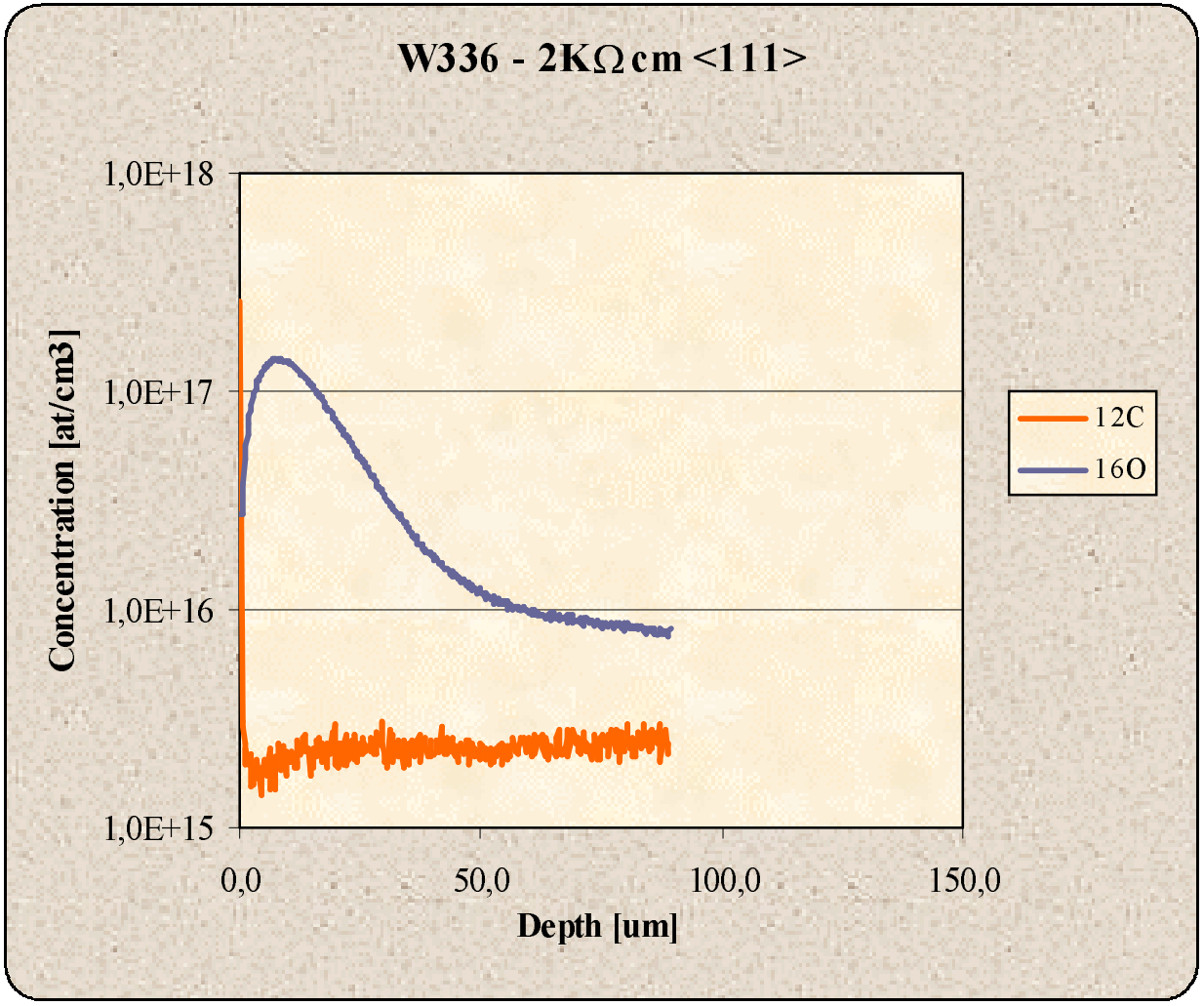
SIMS Measurements - standard samples



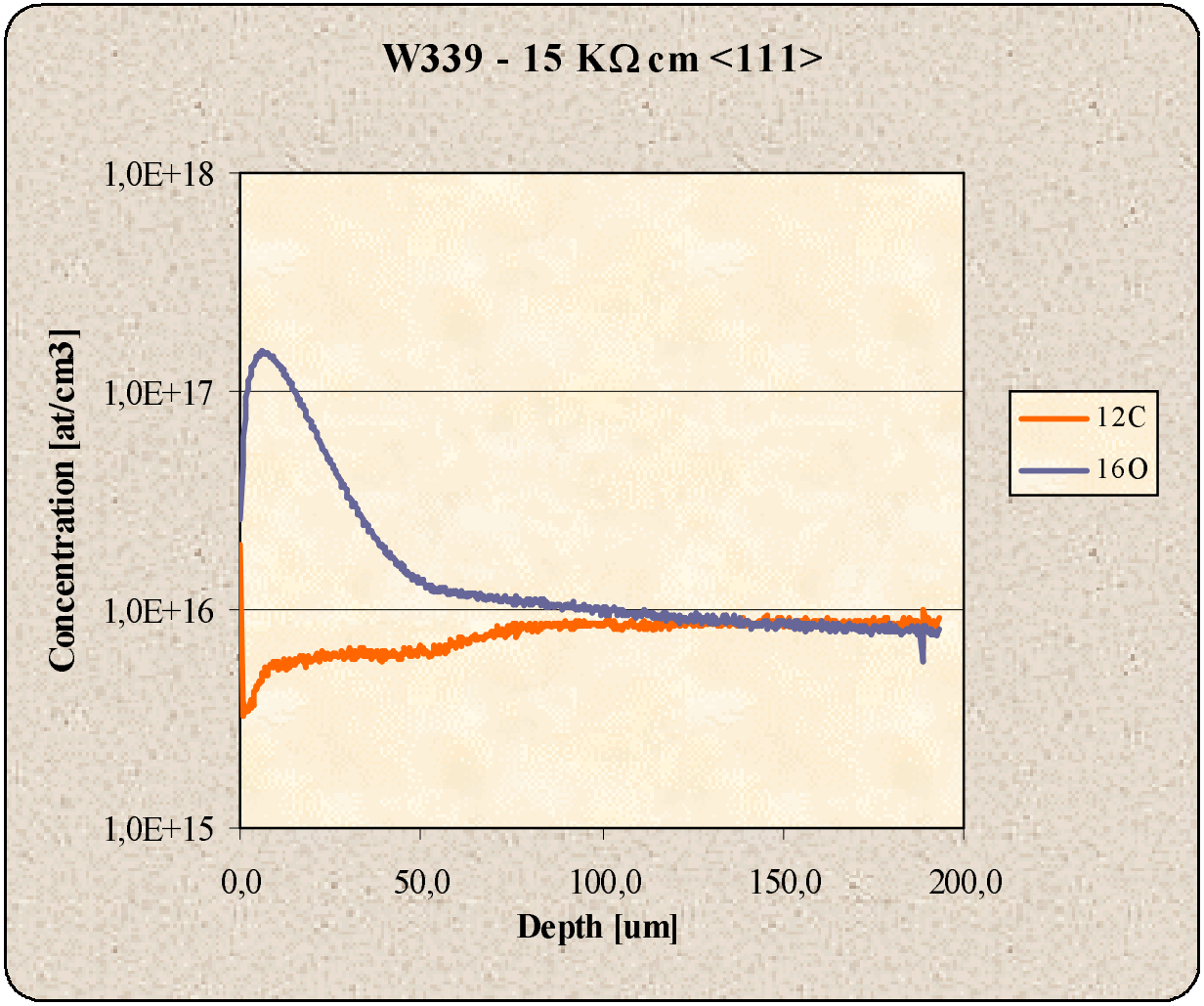
SIMS Measurements - standard samples



SIMS Measurements - standard samples



SIMS Measurements - standard samples

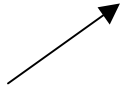


Oxygenated and Standard diodes

Diodes produced by ST Microelectronics (Catania, Italy)

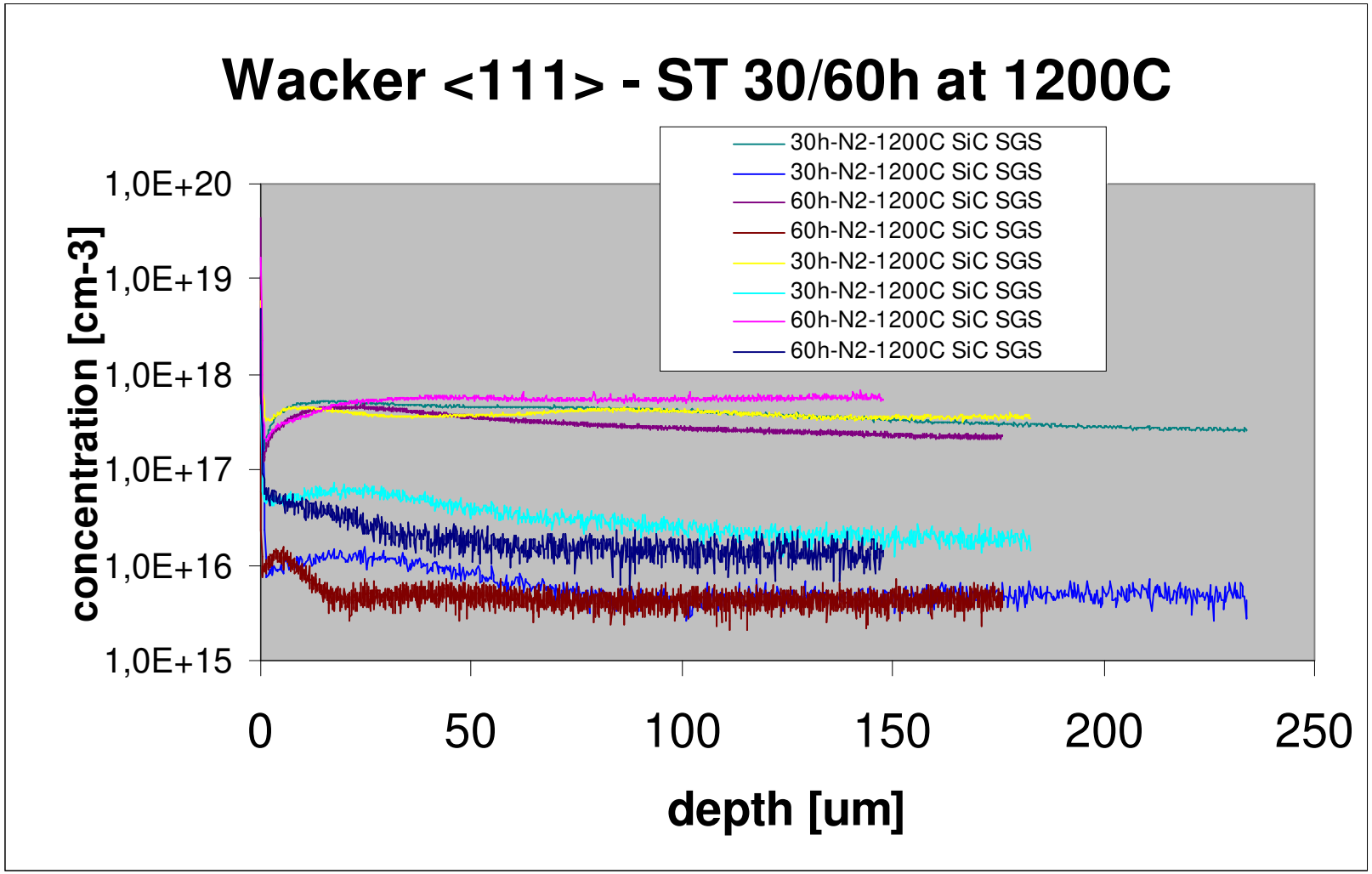
ID	Wafer	Silicon	Orientation	rho [KΩcm]	Treatment	SIMS [O]	SIMS [C]	IRR-scenario	[O]/[C]
W301-T	5"	Wacker	<111>	1,03	60h-N2-1200C SiC			PS-7/99	
W305-T	5"	Wacker	<100>	1	60h-N2-1200C SiC			PS-7/99	
W306-T	5"	Wacker	<111>	1,01	30h-N2-1200C SiC			PS-7/99	
W309-T	5"	Wacker	<111>	2	60h-N2-1200C SiC	5,50E+17	1,20E+16	PS-8/99	46
W311-T	5"	Wacker	<100>	1,1	30h-N2-1200C SiC			PS-7/99	
W316-T	5"	Wacker	<111>	2,24	30h-N2-1200C SiC	3,70E+17	2,30E+16	PS-7/99 PS-8/99	16
W317-T	5"	Wacker	<111>	15	60h-N2-1200C SiC			PS-7/99	
W319-T	5"	Wacker	<100>	2,4	60h-N2-1200C SiC	2,30E+17	5,40E+15	PS-7/99 PS-8/99	43
W320-T	5"	Wacker	<100>	2,42	30h-N2-1200C SiC	3,40E+17	1,00E+16	PS-7/99 PS-8/99	34
W324-T	5"	Wacker	<111>	15,6	30h-N2-1200C SiC			PS-7/99	

ID	Wafer	Silicon	Orientation	rho [KΩcm]	Treatment	SIMS [O]	SIMS [C]	IRR-scenario	
W330-T/ W331-T	5"	Wacker	<100>	1	reference	4,70E+15	3,20E+15	PS-11/99	1
W332-T/W333-T	5"	Wacker	<111>	1	reference	1,00E+16	2,10E+15	PS-11/99	5
W334-T/W335-T	5"	Wacker	<100>	2	reference	8,60E+15	2,90E+15	PS-11/99	3
W336-T/W337-T	5"	Wacker	<111>	2	reference	8,00E+15	2,40E+15	PS-11/99	3
W338-T/W339-T	5"	Wacker	<111>	15	reference	8,60E+15	8,40E+15	PS-11/99	1



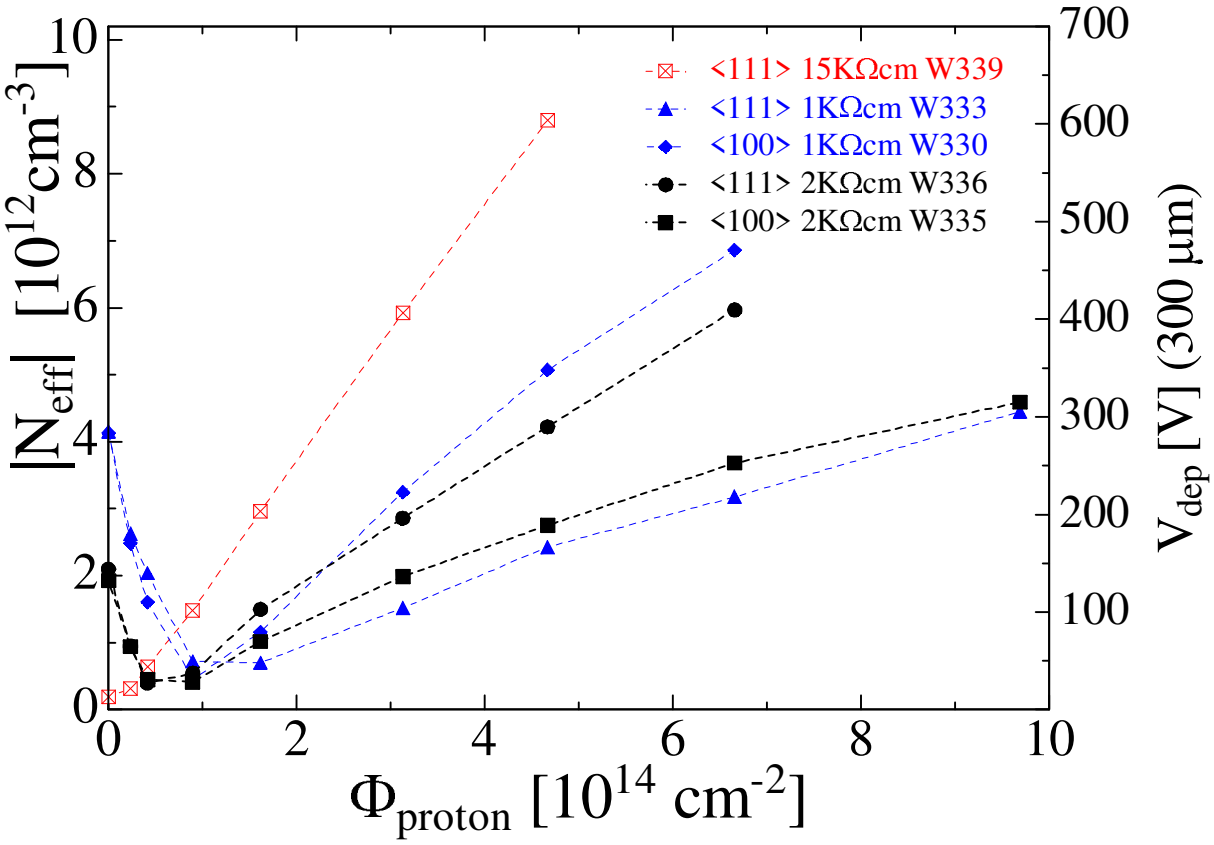
be careful with the ratio [O]/[C] - [C] close to or below detection limit !!!

SIMS Measurements - oxygenated samples



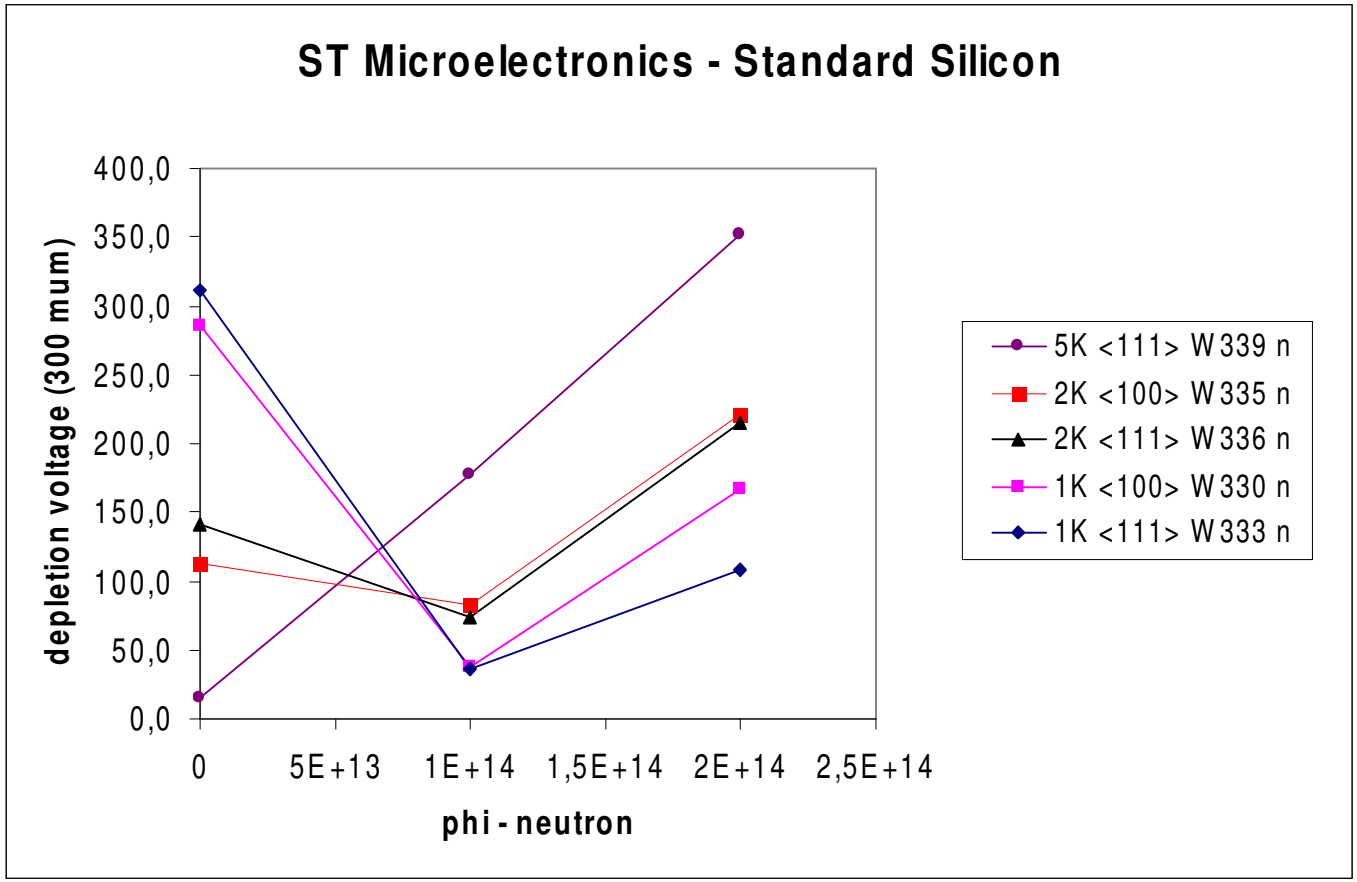
ST Microelectronics - standard diodes

- Different resistivities and crystal orientations



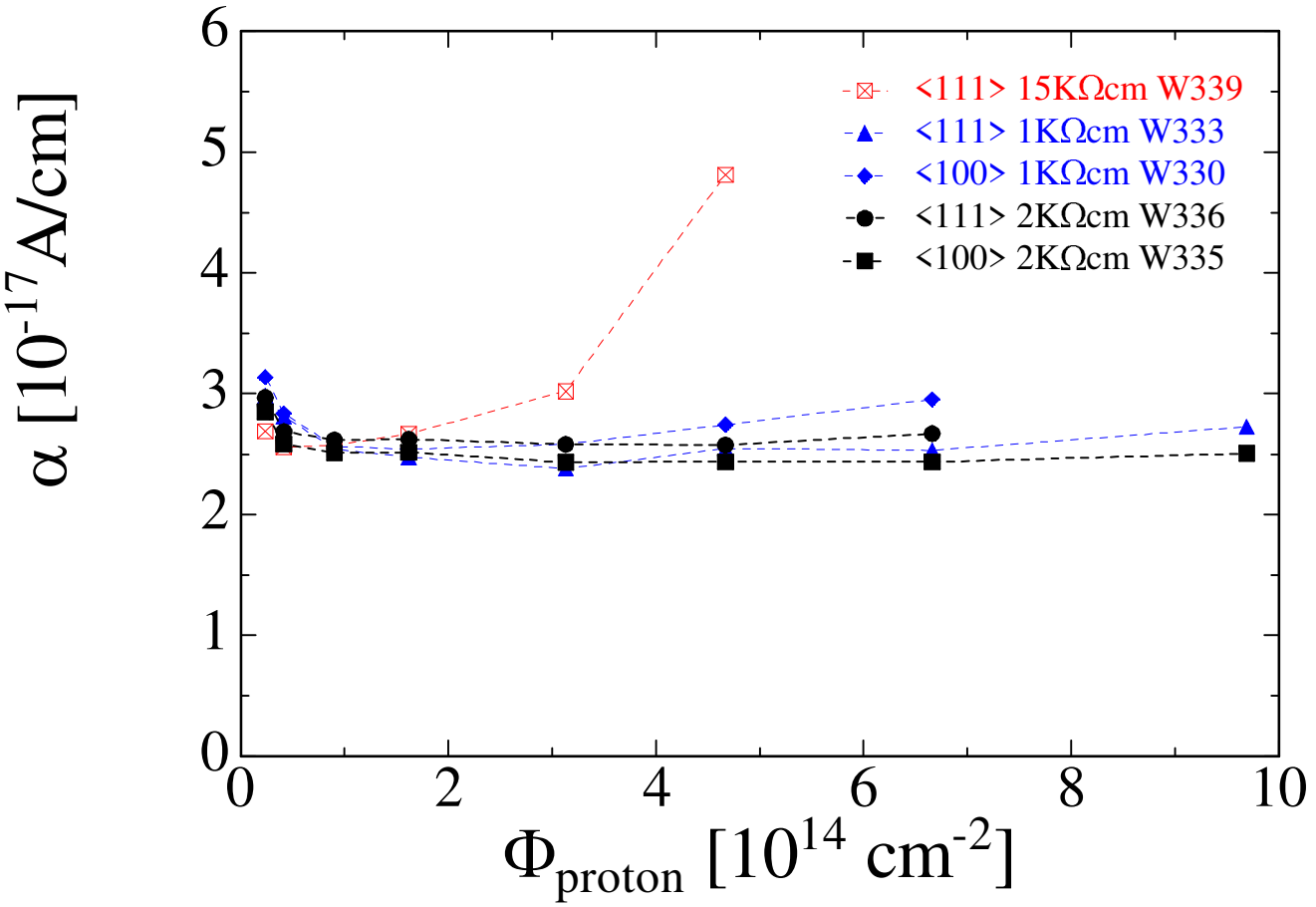
ST Microelectronics - Standard diodes

- Different resistivities and crystal orientations
- Neutron irradiation (Ljubljana) + 4min annealing at 80ºC



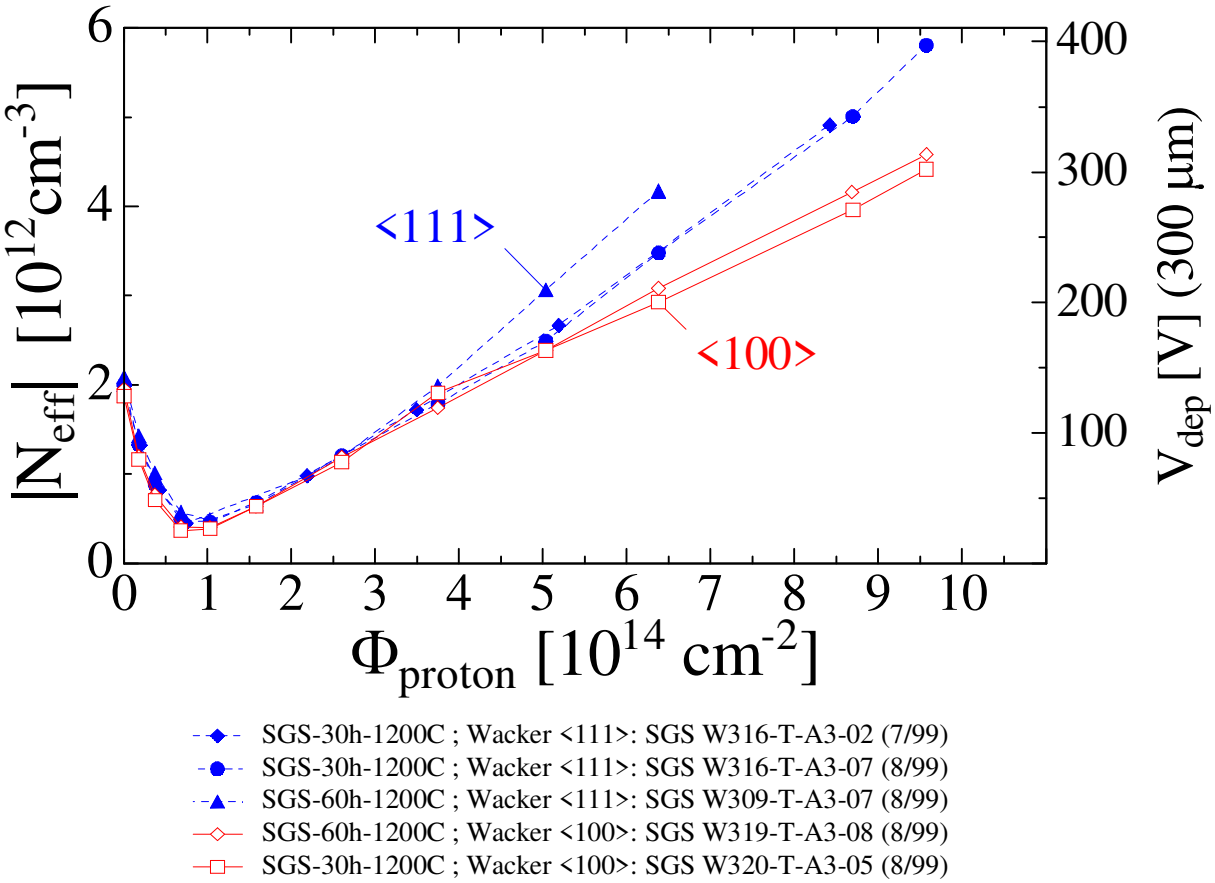
ST Microelectronics - standard diodes

- Different resistivities and crystal orientations
- *α - value taken at depletion voltage*



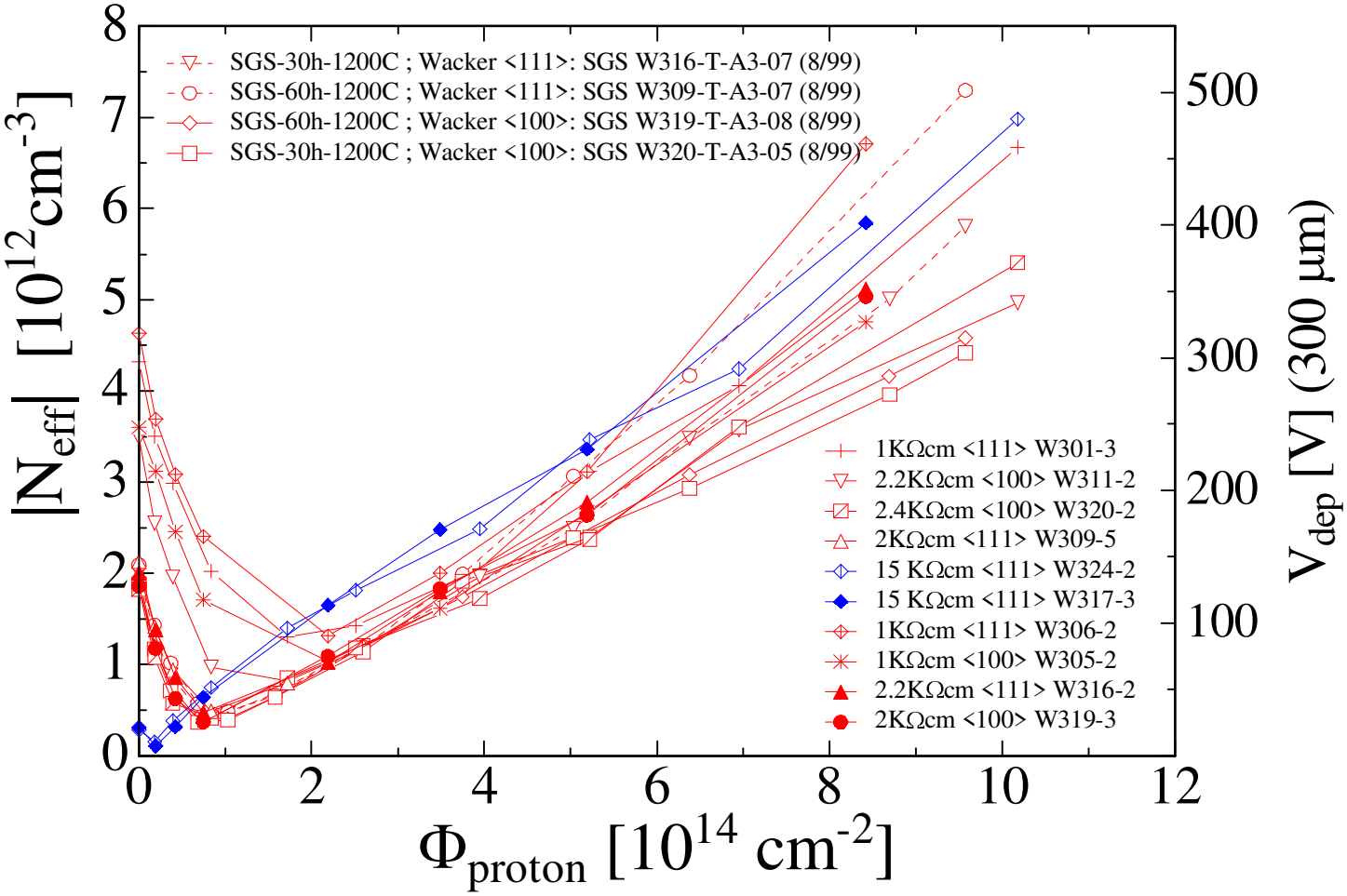
ST Microelectronics - oxygenated diodes

- Different orientations <111> and <100>



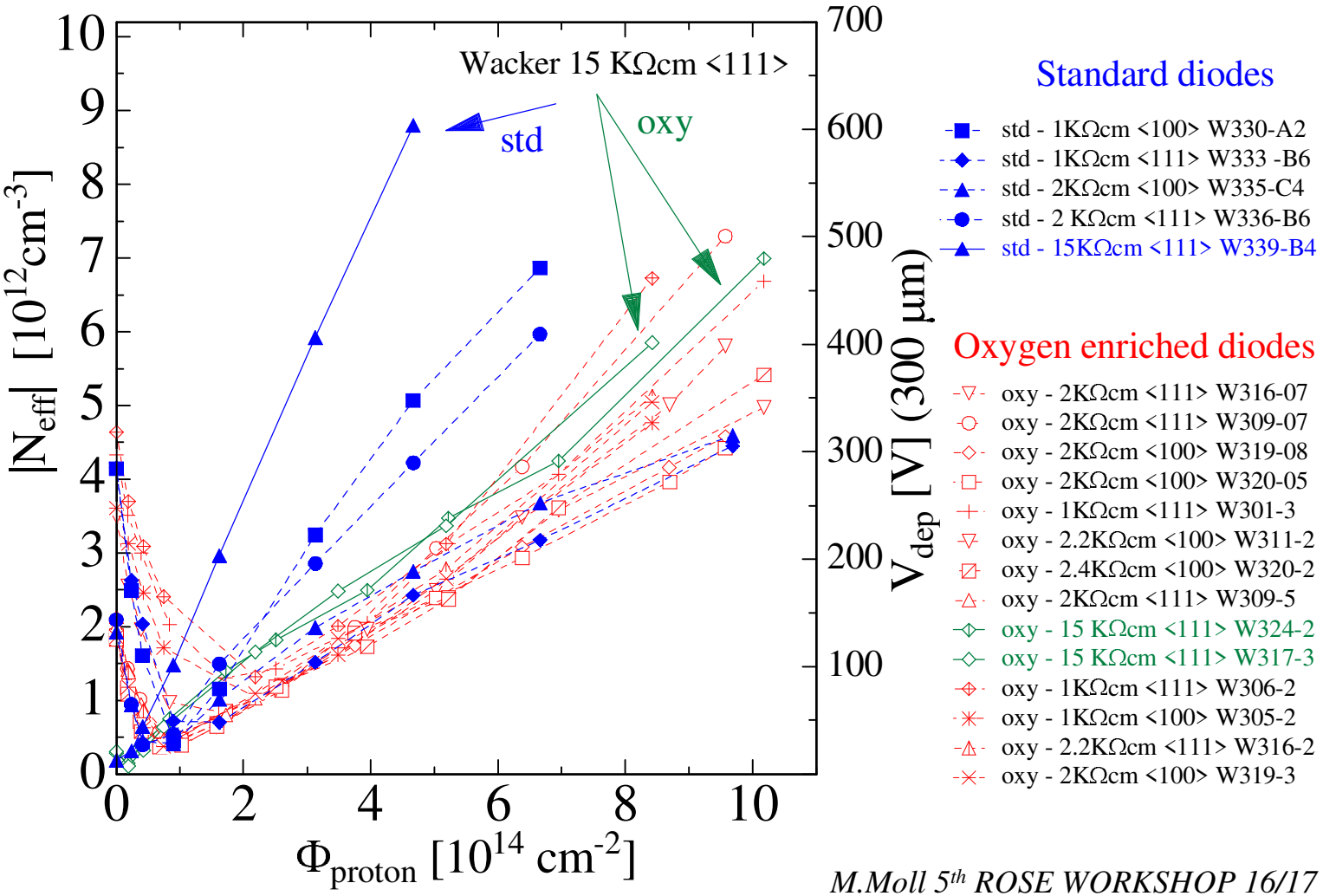
ST Microelectronics - oxygenated diodes

- Different resistivities and crystal orientations



Comparison: standard and oxygenated diodes

- Oxygen enriched diodes do not show a big variation in V_{dep}

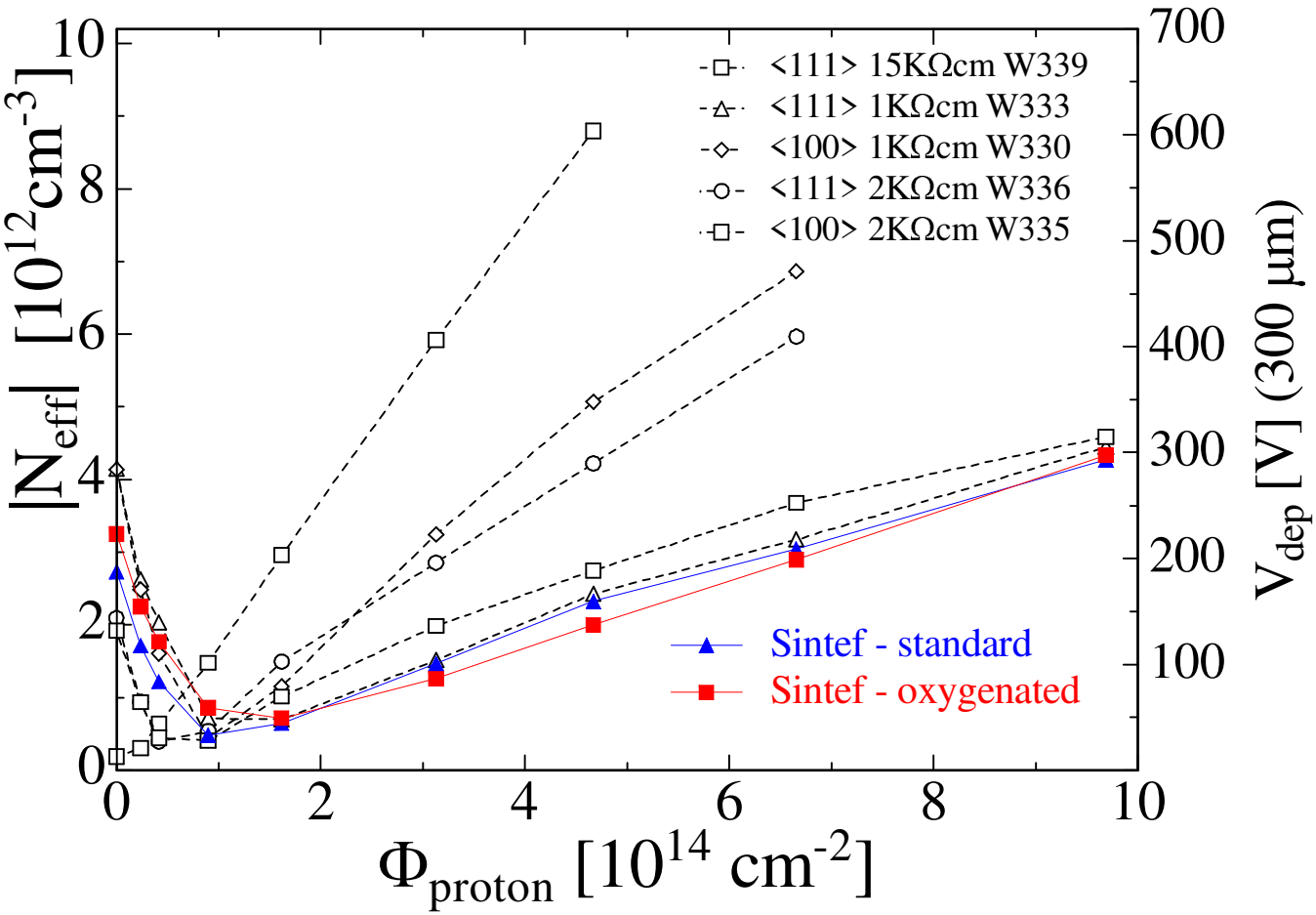


Sintef diodes
Material / Diodes / Irradiations

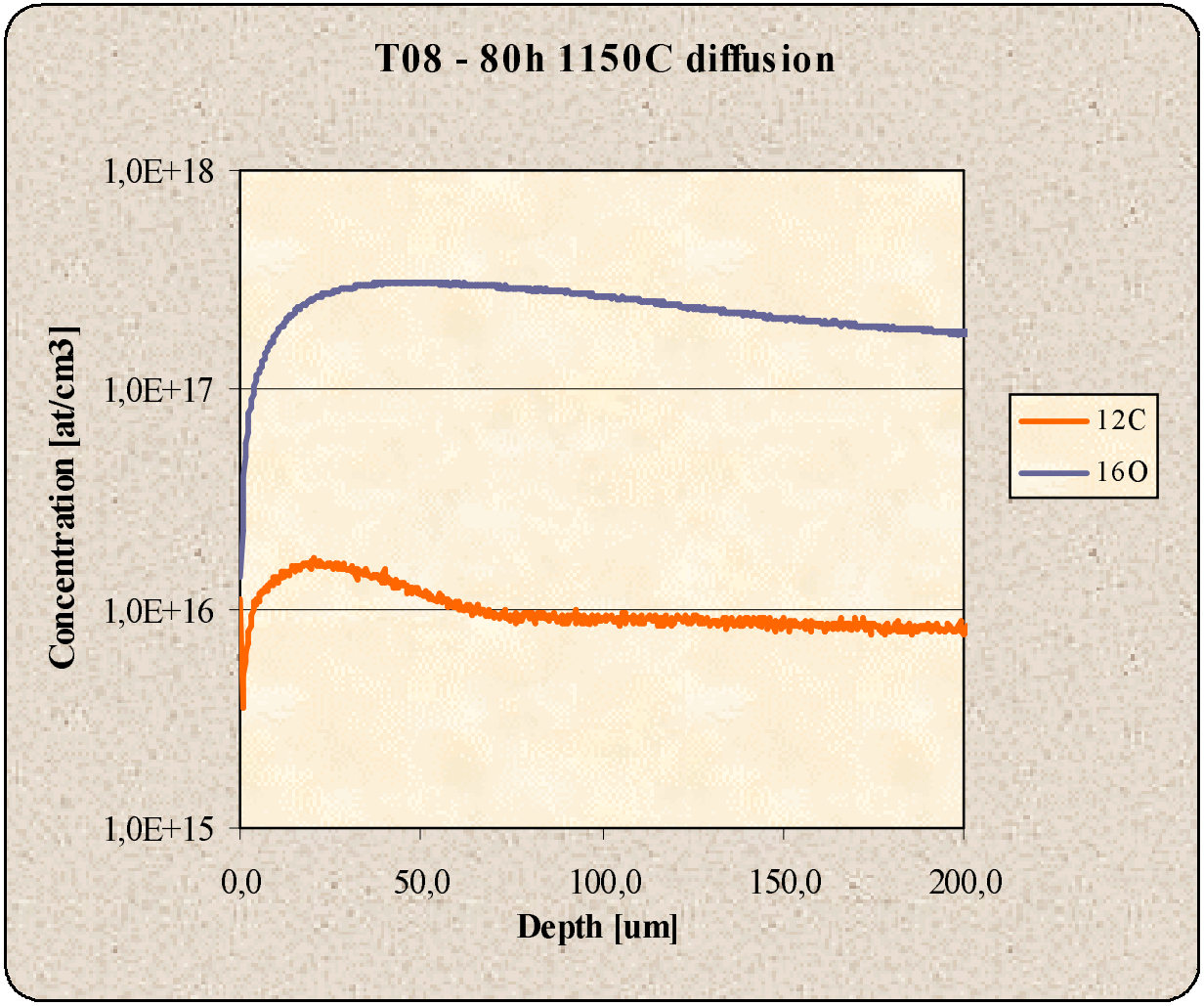
- Topsil silicon
- Orientations: <100>
- Resistivity: 1KΩcm
- Diode producer: Sintef - ROSE mask
- Two batches:
  - 1.) No oxygen enrichment ⇒ Standard diodes
  - 2.) Oxygen enrichment ⇒ Oxygenated diodes
    (80h at 1150ºC)
- Irradiation: CERN PS 24GeV/c protons

Sintef - standard and oxygenated diodes

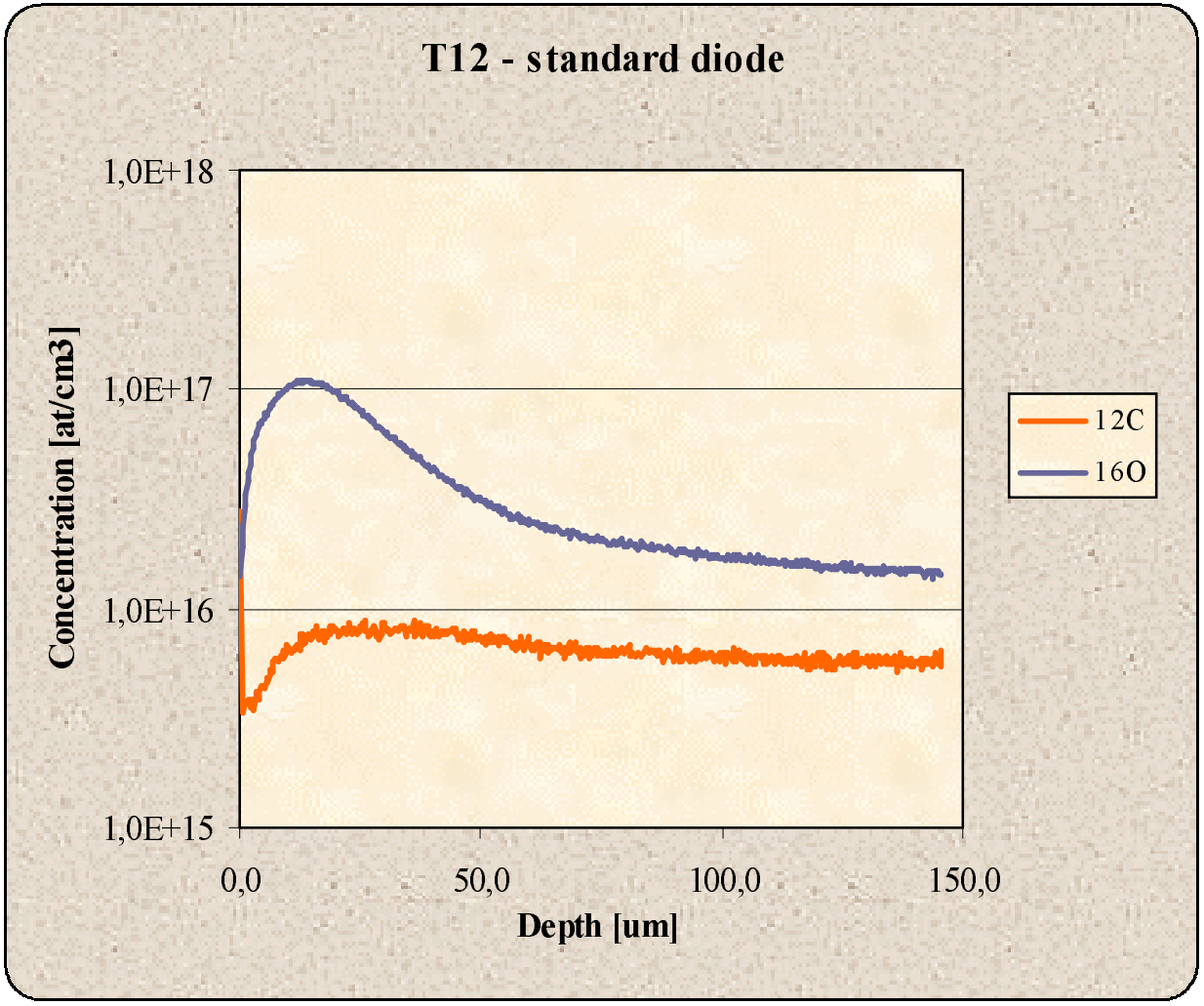
- No difference between oxygenated and standard diode ?



SIMS Measurements - oxygenated samples



SIMS Measurements - standard samples



Conclusion

- Sintef and ST Microelectronics std/oxygenated diodes tested with 24 GeV/c protons

- All oxygenated diodes found to be “radiation hard” !!
  $\Rightarrow$ A high oxygen content [O] $>1\times10^{17}cm^{-3}$ leads to “radiation hardness”.

- Strong variation of radiation hardness of “standard” diodes !
- Material with a low oxygen content [O] $\approx1\times10^{16}cm^{-3}$ can be “radiation hard”
  $\Rightarrow$ Is the ratio between O and C - concentration determining the radiation hardness of the silicon diodes ?