Properties of irradiated semi-insulating GaN

J.Vaitkus (1), J.P.Grant (2), E.Gaubas (1), V.Kazukauskas(1), V.Kalendra(1), K.Kazlauskas(1), S.Sakai (3), J.Storasta(1)

(1) Institute of Materials Science and Applied Research, Vilnius University, Lithuania;
(2) Dept. Physics and Astronomy, Glasgow University, Scotland,
(3) Dept. Engineering, Tokushima University, Tokushima, Japan.

Introduction:

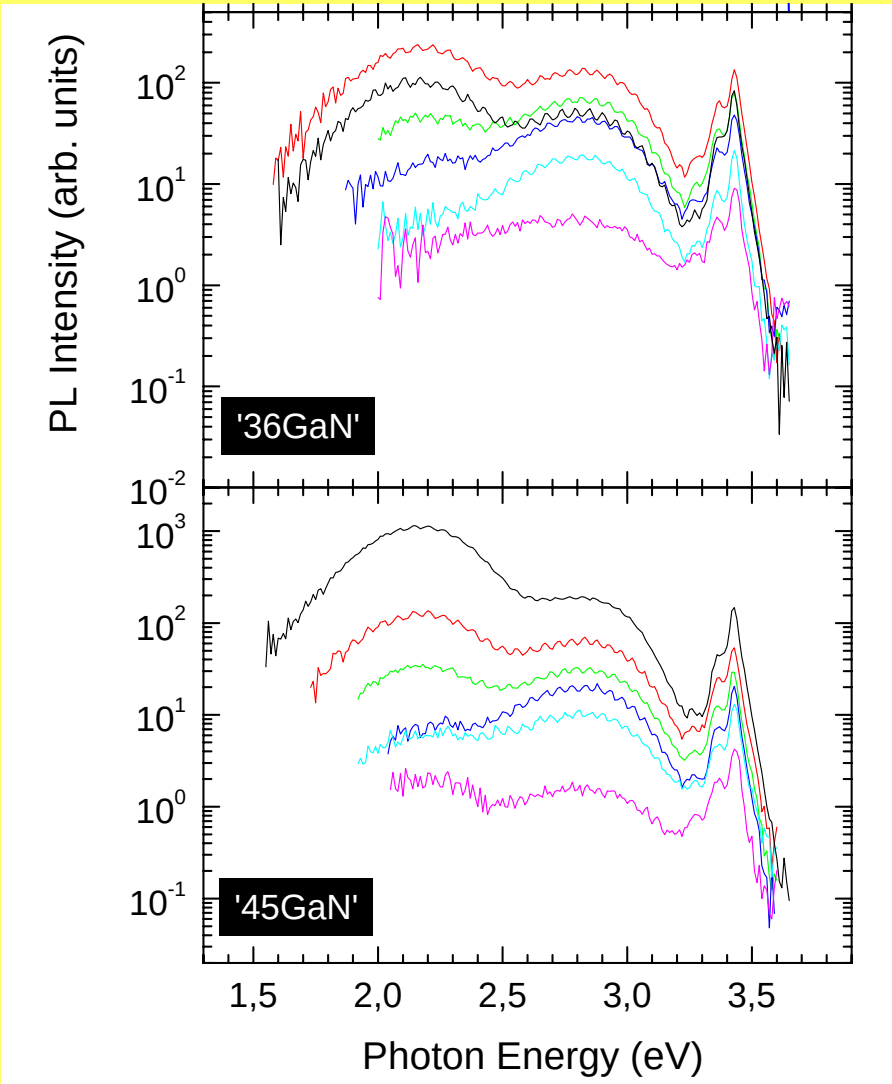
- According known material properties GaN was proposed to have an ability to be radiation hard material.
- In previous talk it was demonstrated that C.C.E. can reach 40% in highly (1e16 cm^{-2}) irradiated sample.
- What properties are changing and where are the problems to become the detector?

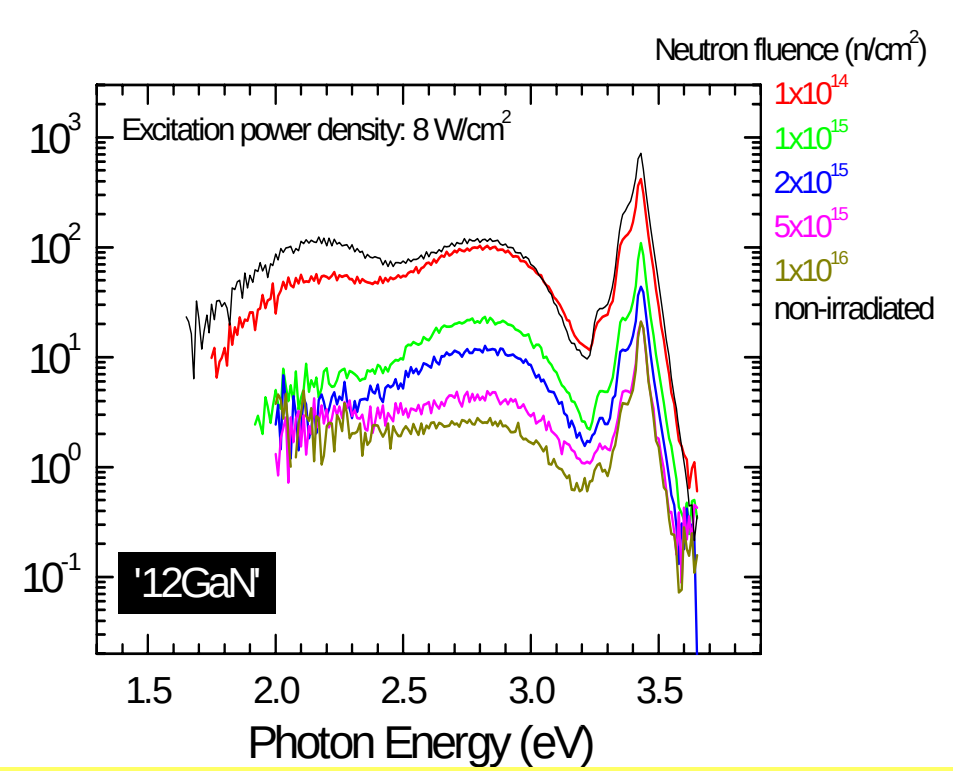
The results of investigation of SI-GaN by:
photluminescence,
photoconductivity spectra and kinetics,
microwave absorption kinetics
thermally stimulated current.

The samples were irradiated:
by neutrons

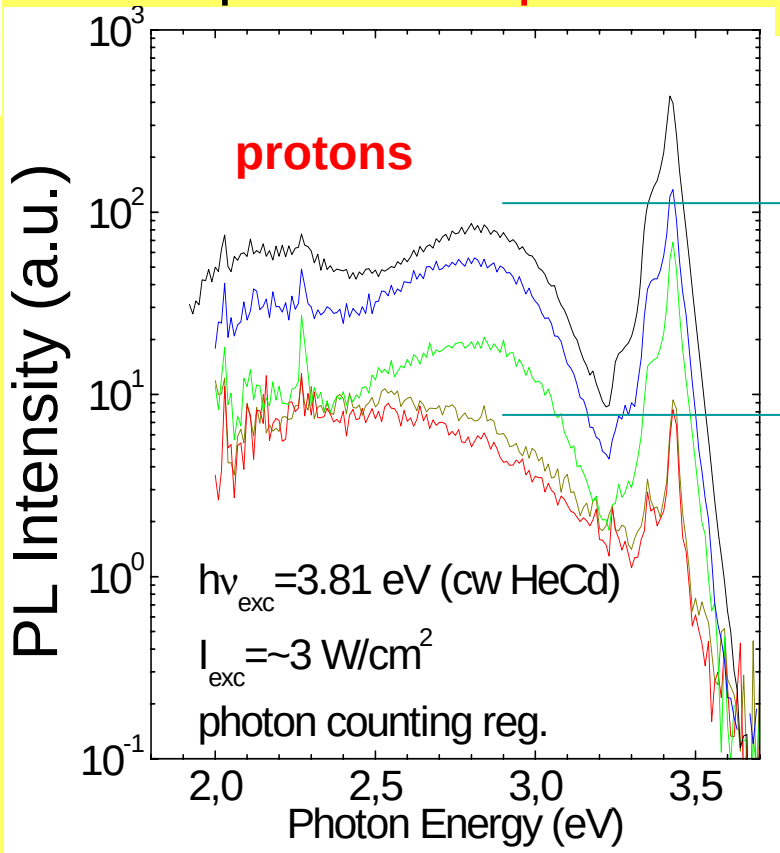
and compared with data for the similar samples
irradiated by proton and neutron earlier.

Photoluminescence spectra in **neutron** irradiated GaN samples



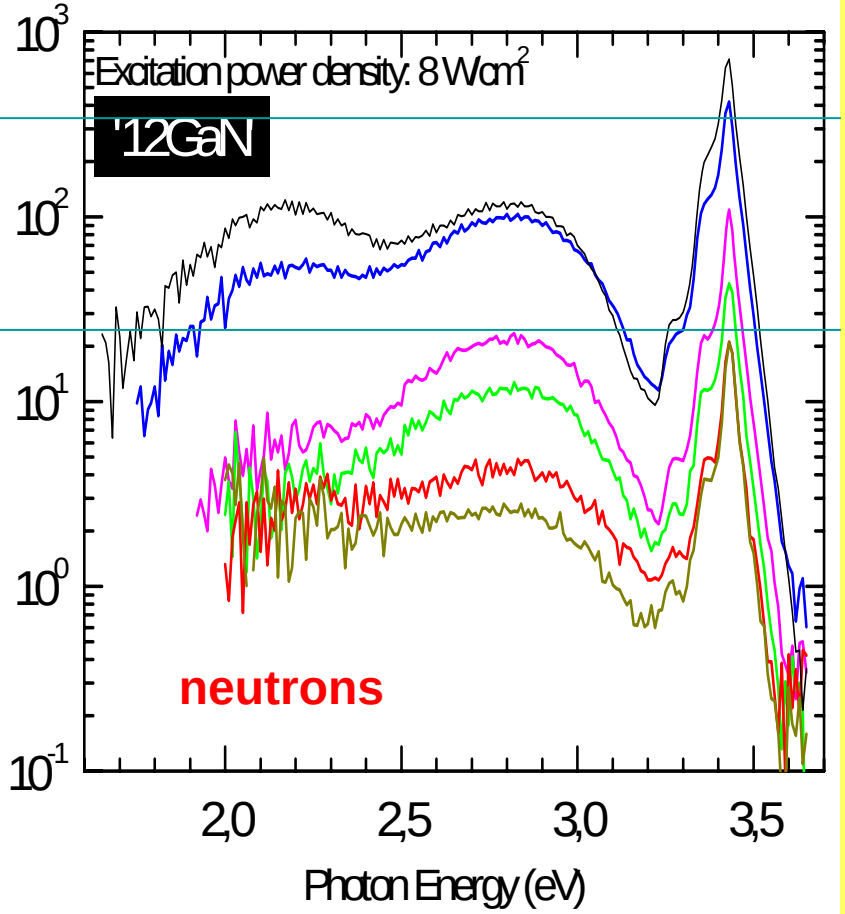


Comparison of proton and neutron irradiation in SI-GaN



24 Gev/c proton irradiated by fluences

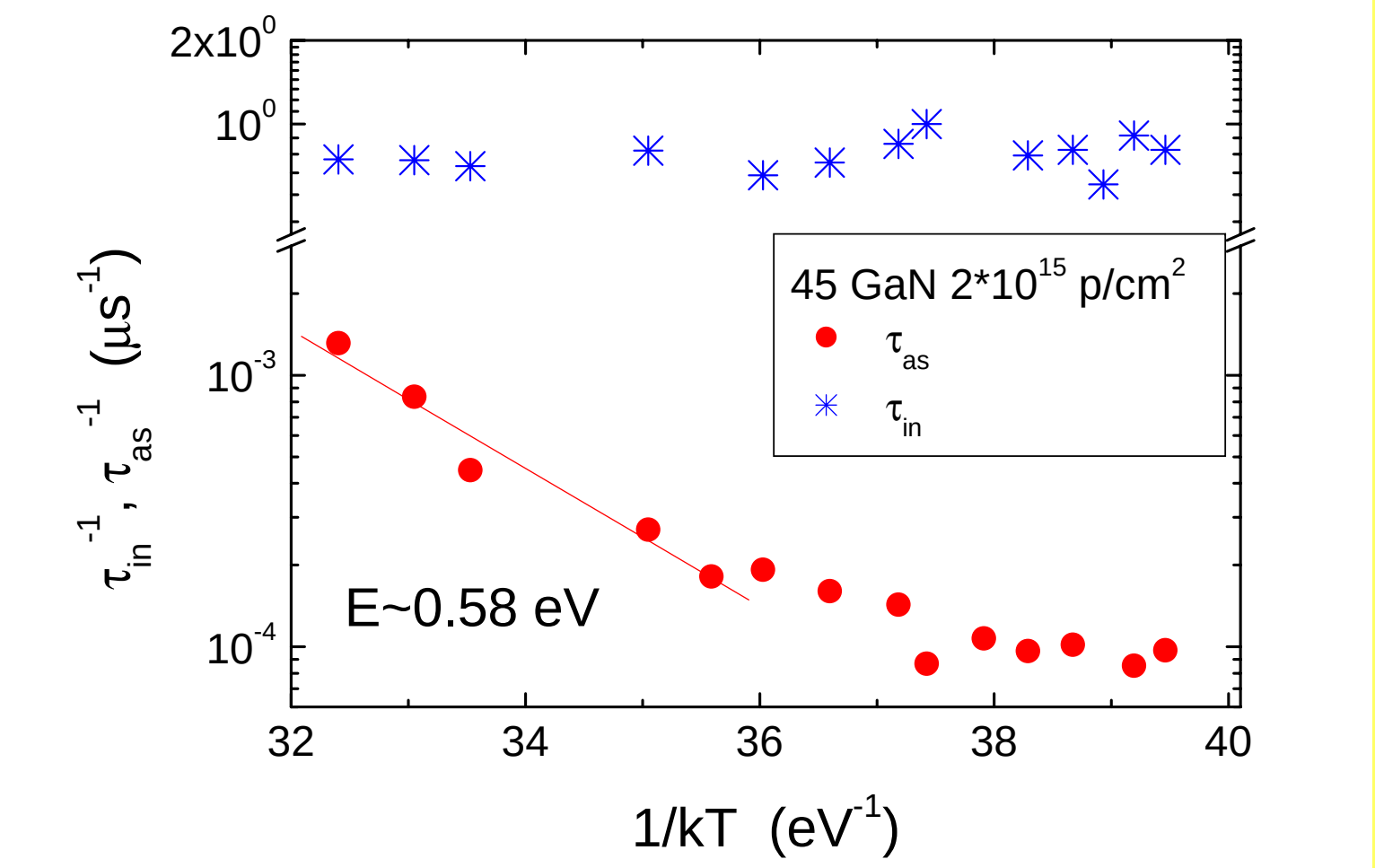
- 783 H^+: 1.05*10^{16} cm^{-2}
- 784 H^+: 5.63*10^{15} cm^{-2}
- 786 H^+: 1.80*10^{15} cm^{-2}
- 787 H^+: 1.15*10^{14} cm^{-2}
- non-irradiated (~4,2 W/cm^{-2})



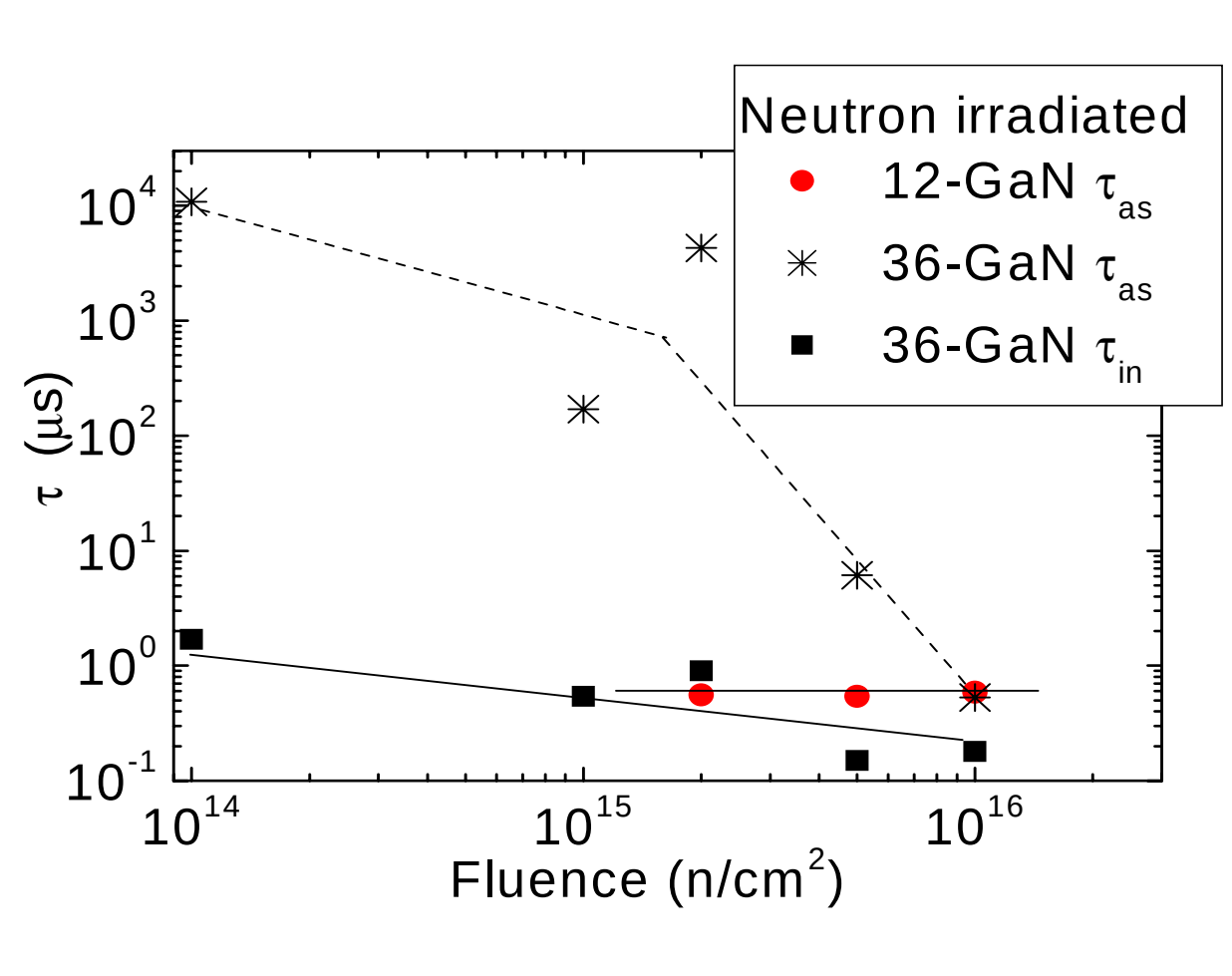
Neutron fluence (n/cm^2)

- 1x10^{14}
- 1x10^{15}
- 2x10^{15}
- 5x10^{15}
- 1x10^{16}
- non-irradiated

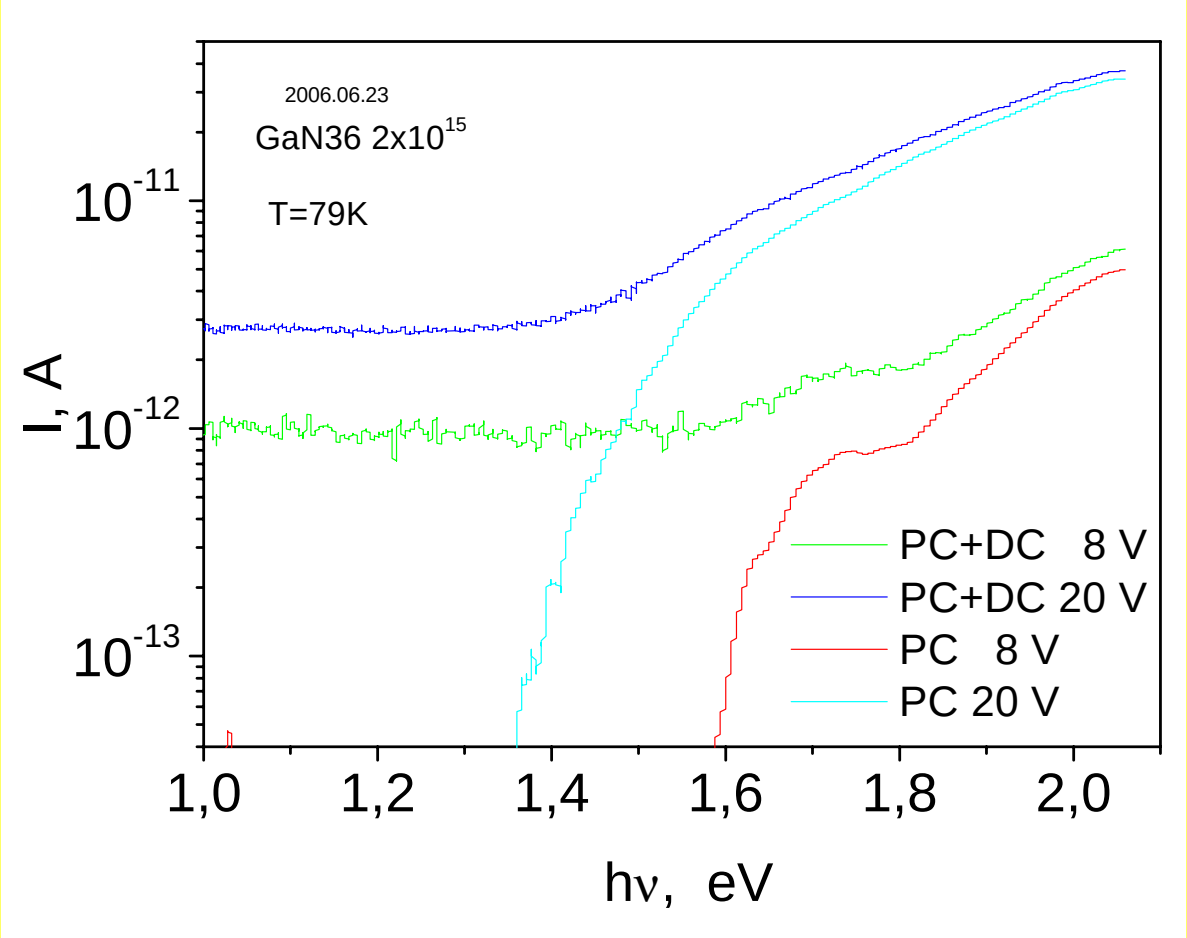
Decay time constants dependence on T



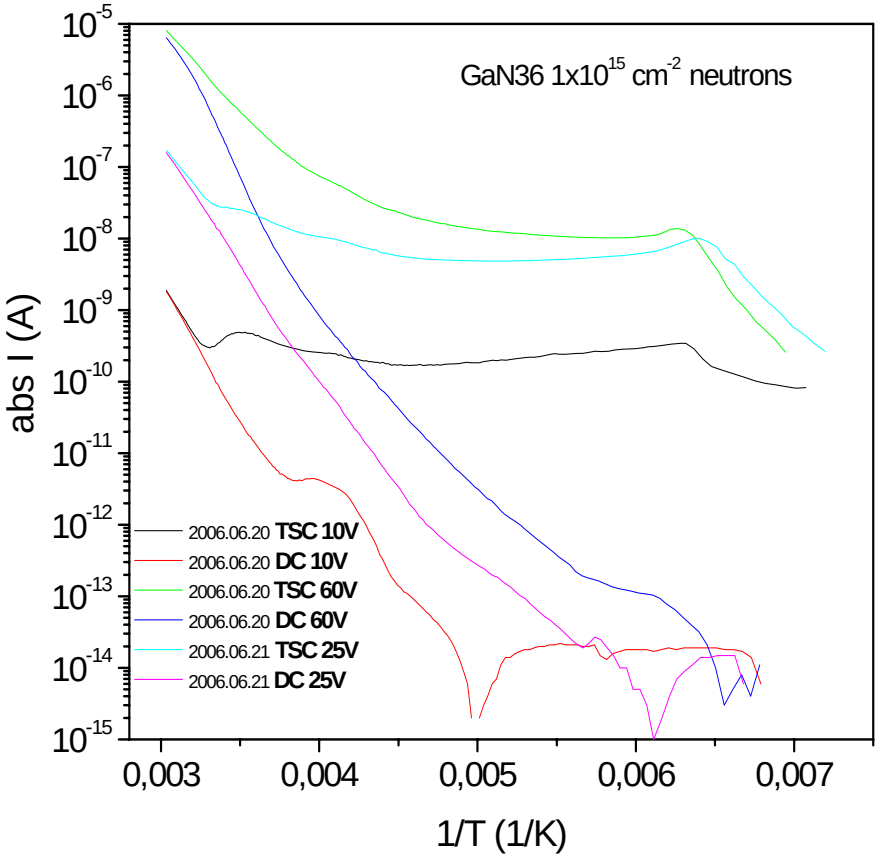
PC decay constants

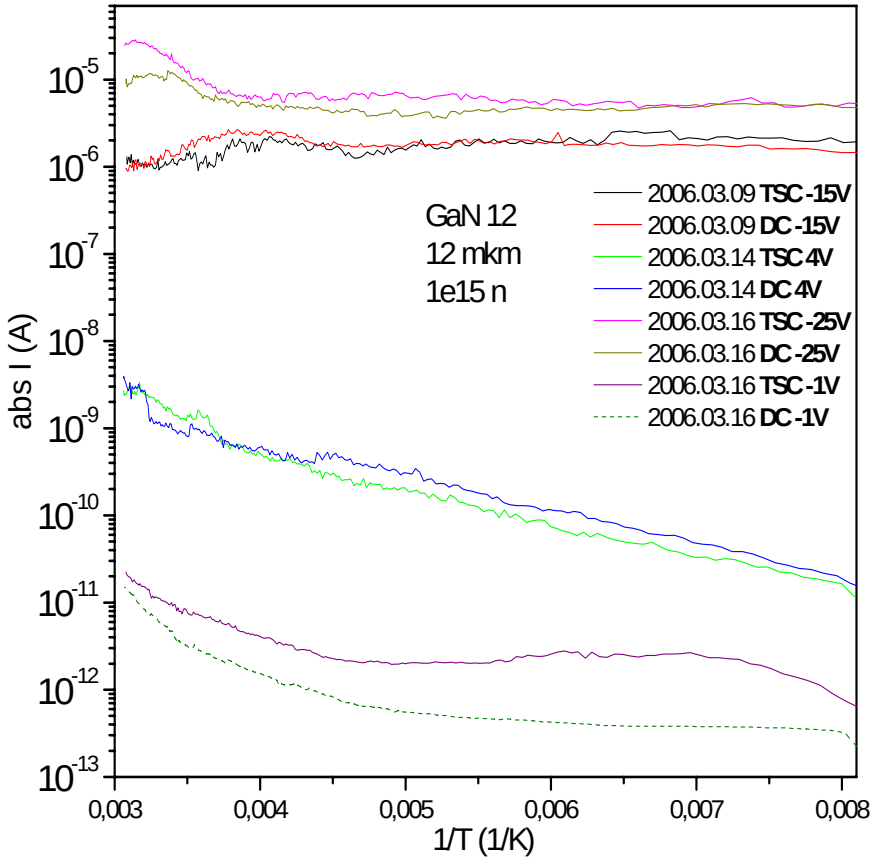


GaN PC

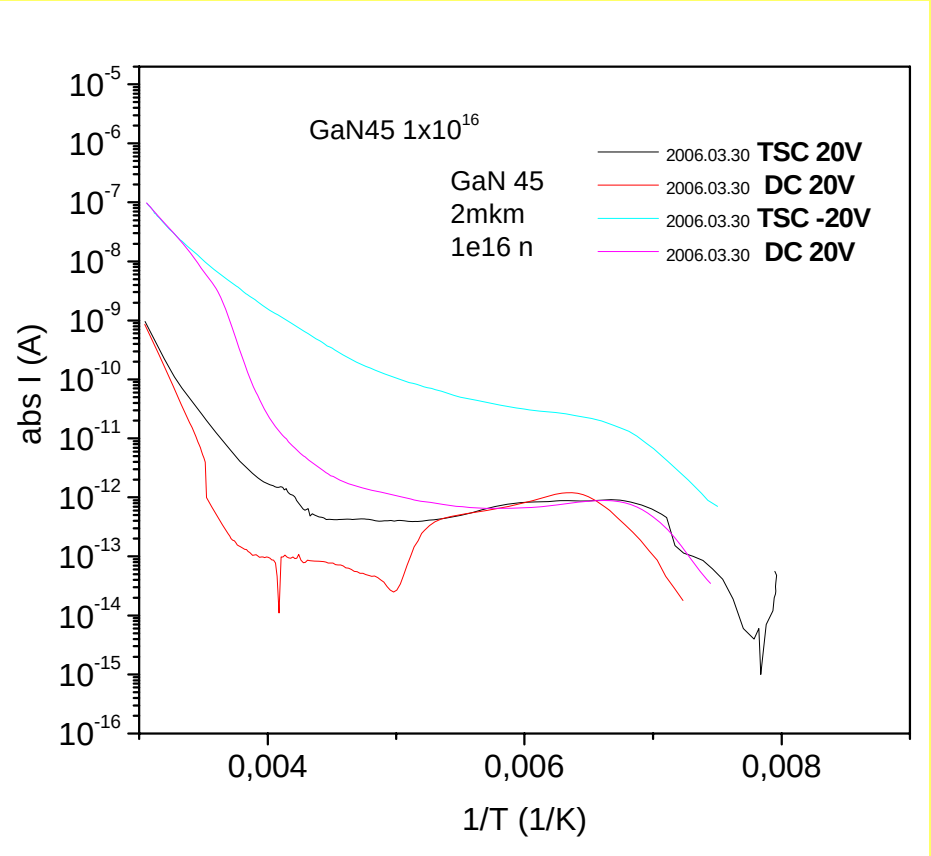

2006.06.23
GaN36 2x10^15
T=79K
I, A
10^-11
10^-12
10^-13
1,0
1,2
1,4
1,6
1,8
2,0
hν, eV
PC+DC 8 V
PC+DC 20 V
PC 8 V
PC 20 V

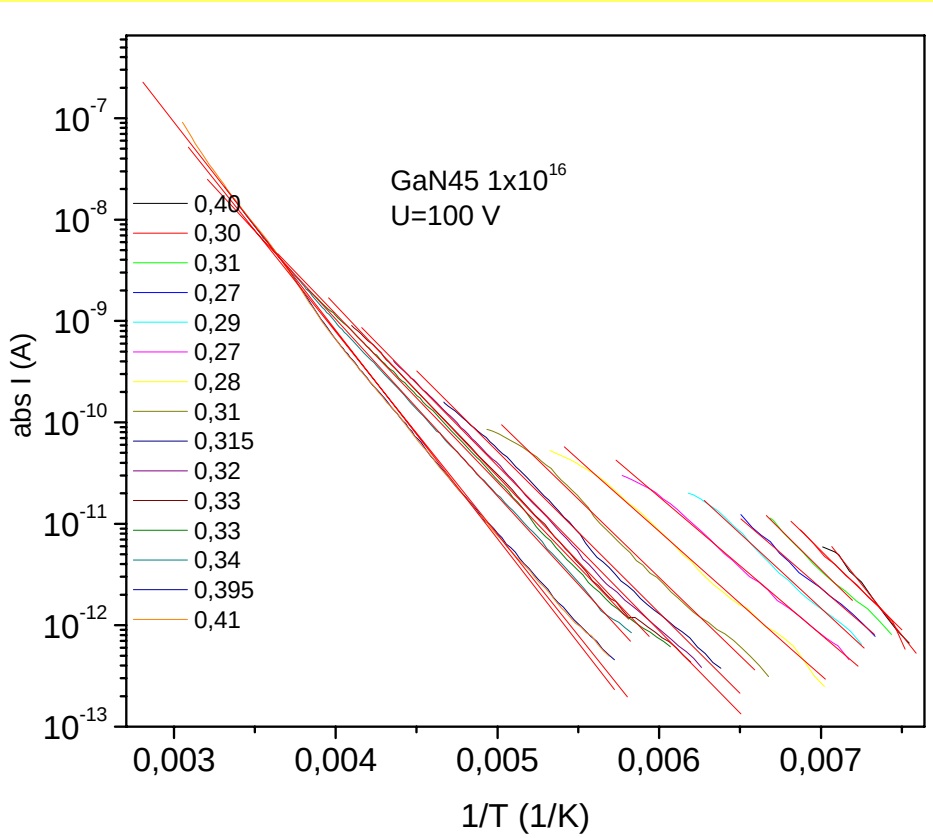
TSC


GaN36 1x10^15 cm^-2 neutrons
abs I (A)
1/T (1/K)
2006.06.20 TSC 10V
2006.06.20 DC 10V
2006.06.20 TSC 60V
2006.06.20 DC 60V
2006.06.21 TSC 25V
2006.06.21 DC 25V

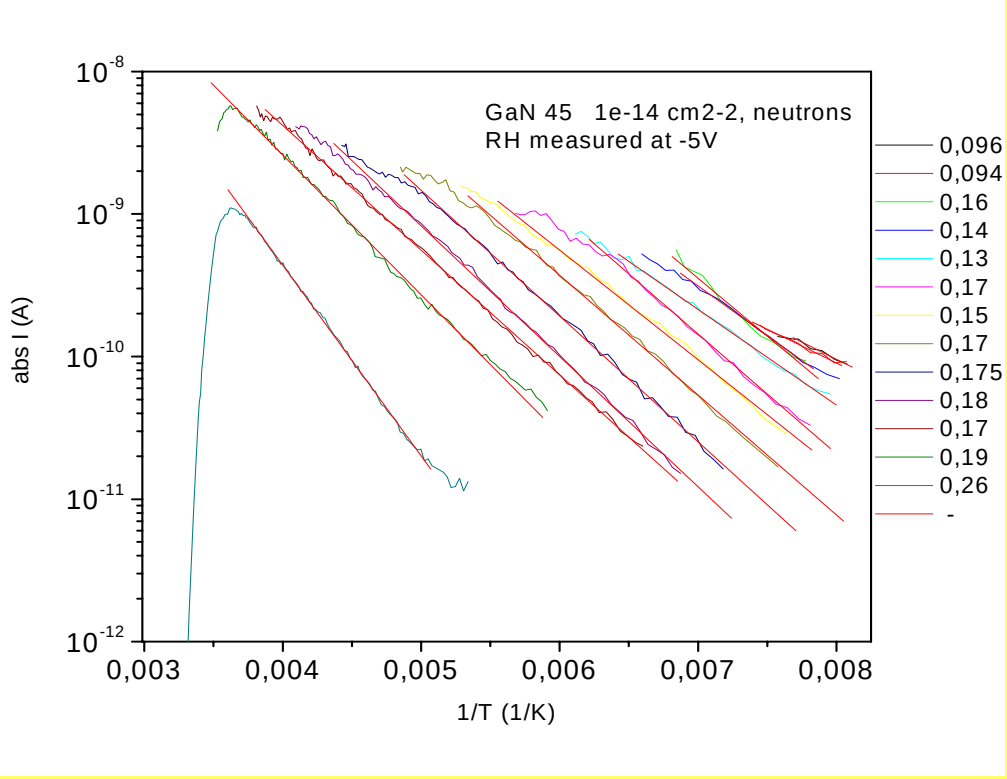

GaN 12
12 mkm
1e15 n
abs I (A)
1/T (1/K)
2006.03.09 TSC -15V
2006.03.09 DC -15V
2006.03.14 TSC 4V
2006.03.14 DC 4V
2006.03.16 TSC -25V
2006.03.16 DC -25V
2006.03.16 TSC -1V
2006.03.16 DC -1V

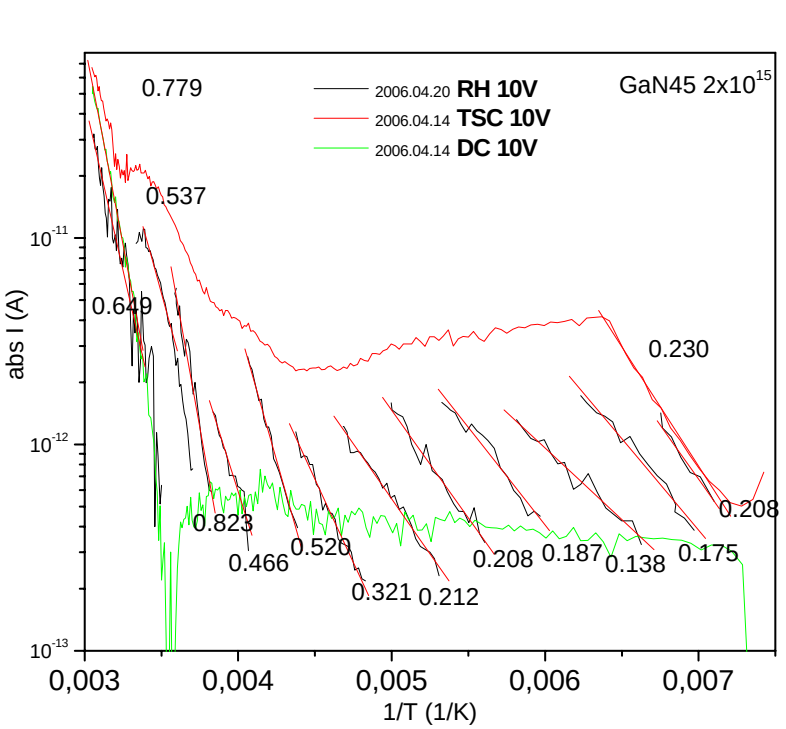
TSC


GaN45 1x10^16
GaN 45
2mkm
1e16 n
2006.03.30 TSC 20V
2006.03.30 DC 20V
2006.03.30 TSC -20V
2006.03.30 DC 20V
abs I (A)
1/T (1/K)

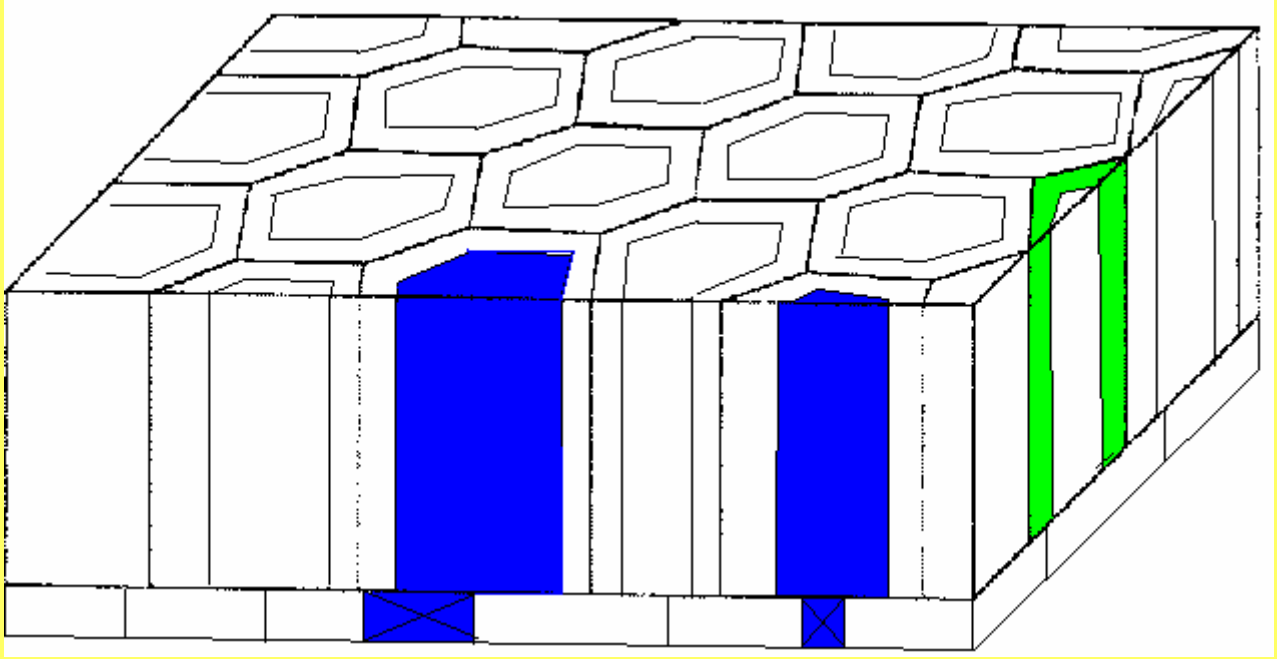

GaN45 1x10^16
U=100 V
0,40
0,30
0,31
0,27
0,29
0,27
0,28
0,31
0,315
0,32
0,33
0,33
0,34
0,395
0,41
abs I (A)
1/T (1/K)

TSC, multiple heating





An “working”model:



Some conclusions (positive):

- The irradiation generates the different defects, but their influence is not crucial: the detectors irradiated by protons and neutrons up to 10^{16} cm^{-2} fluence are alive: CCE ~ 20-40 % (J.Grant talk);

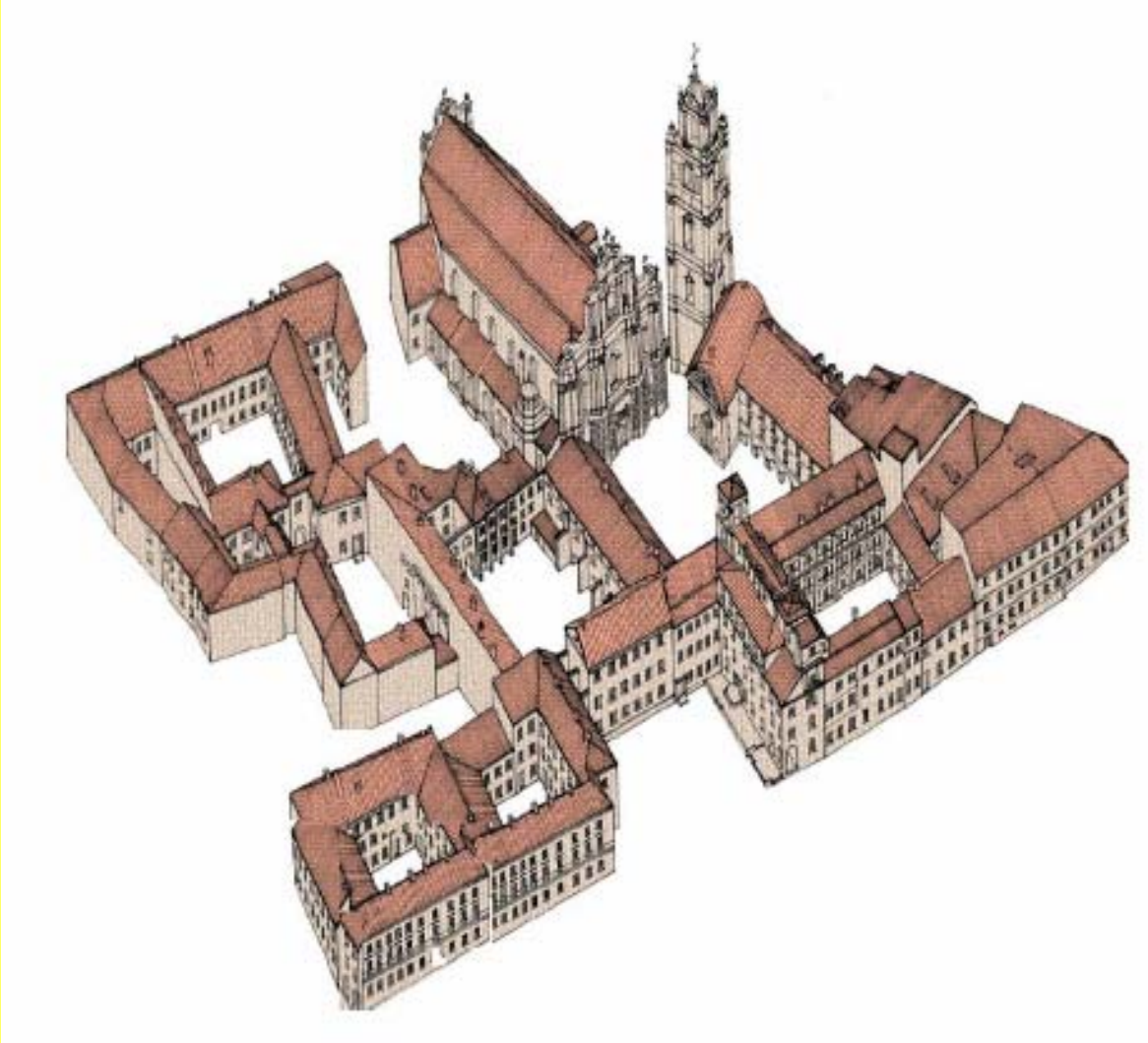
- The substrate related defects play most important role and the detector properties were improved by increasing the epi-layer thickness.

Some conclusions (problematic):

- The contacts problem (injection) is not solved yet.
- Also, it is necessary to change the sapphire substrate (exclude Al), therefore this has a priority to contact problem (that will be necessary to solve in the new samples).

- Two ways for the detector improvement are proposed (and small financial support is obtained):
  - Growth of SI-GaN on Si
  - Free standing GaN samples.

- Today SI-GaN cannot compete with epi-Si (E.Fretfurst talk) but who knows what will happen in the future (GaN is so "young" material).



Thanks for Your attention !