SiC activities at Linköping University

A. Henry and E. Janzén

SiC : Prof. Erik Janzen
growth (bulk and epi)
defect and characterisation

Nitride : Prof. Bo Monemar
growth
optical characterisation

Electronic Structure :
Prof. L. Johansson
photoemission

Compound Semiconductors :
Prof. Per-Olof Holtz
optical characterisation

Spintronic : Prof. Weimin Chen
Magneto-optic measurements

SiC activities

Growth

Bulk

Sublimation

High temperature CVD

Epitaxy

Horizontal Hot Wall CVD

Vertical Hot Wall CVD

Sublimation Epitaxy

LPE

Simulation

Characterization

Optical

PL, PLE, Time resolved PL,

FTIR, FTPL, CL

Electrical

Hall, IV, CV, DLTS, MCTS

Magnetic resonance

ODMR, EPR

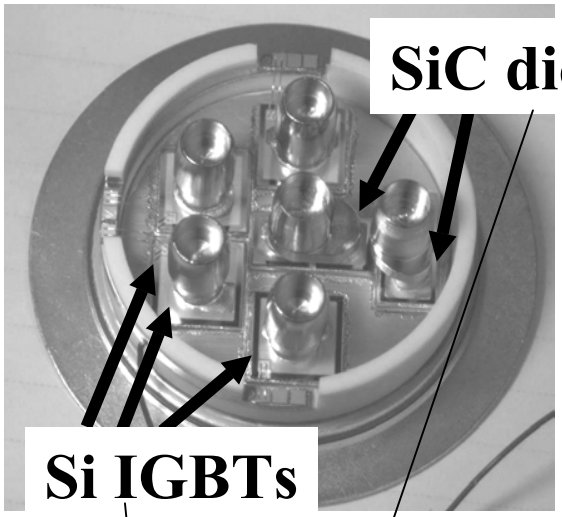
Structural

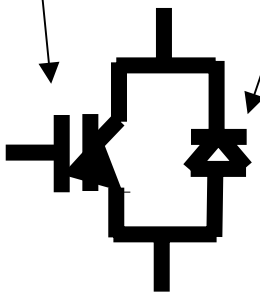
XRD, Lang topograph

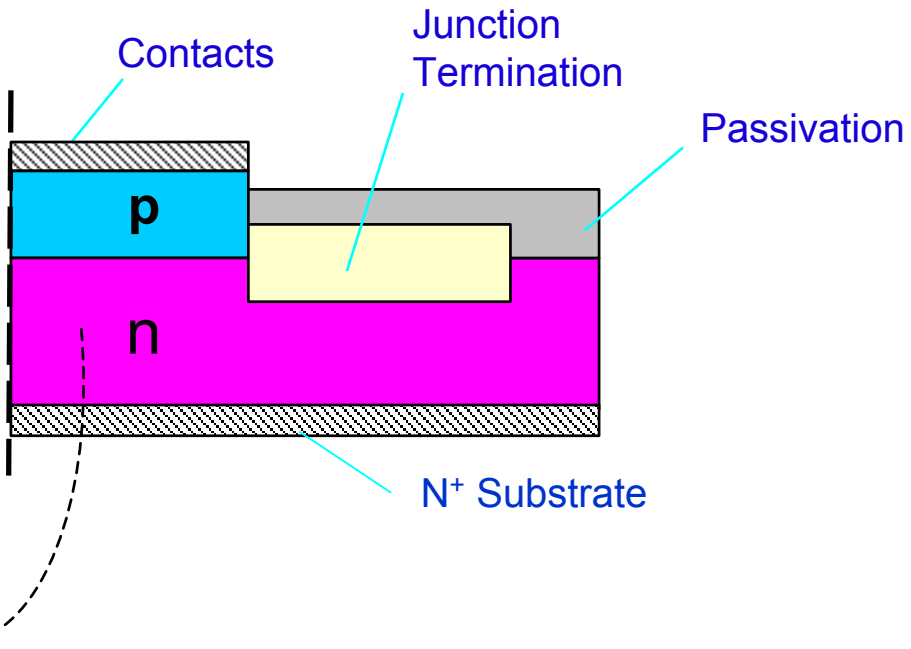
Theoretical calculation

S-Science : Sensor application
Thin Film : TEM
……

High-Power diode







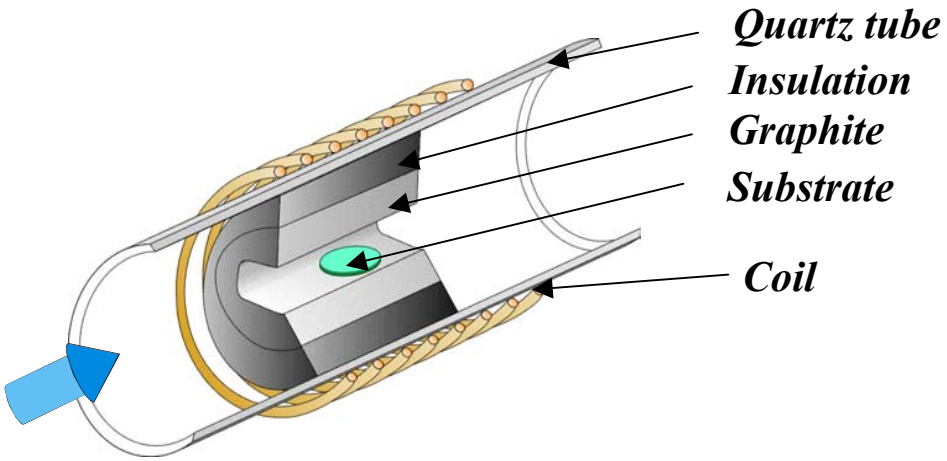
Active layer

2.5kV : 30 μm thick

n^- 1.5E15 cm^{-3}

CVD

Horizontal Hot-Wall CVD ⇒ epilayer



Gas Inlet
H_2 carrier
$SiH_4 + C_3H_8$
Doping (N_2, TMA …)

Growth Temperature:
1600 °C in horizontal

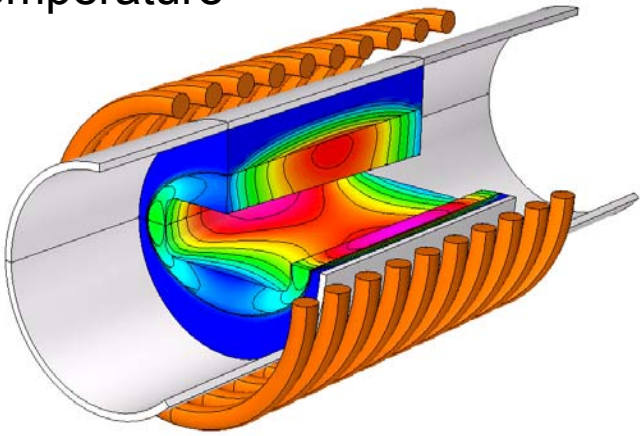
Growth Pressure:
50 - 1000 mbar

O. Kordina
C. Hallin : surf. prep., precursor
U. Forsberg :MESFET
Ö. Danielsson :Simulation

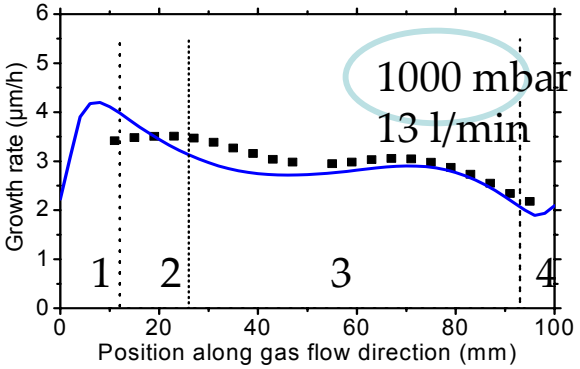
Simulation

Ö. Danielsson

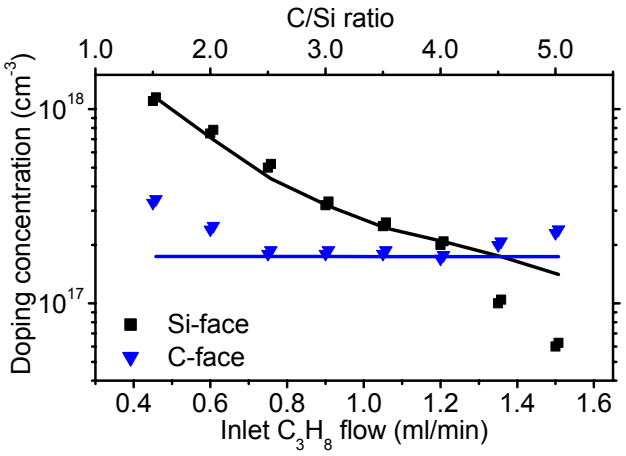
Temperature

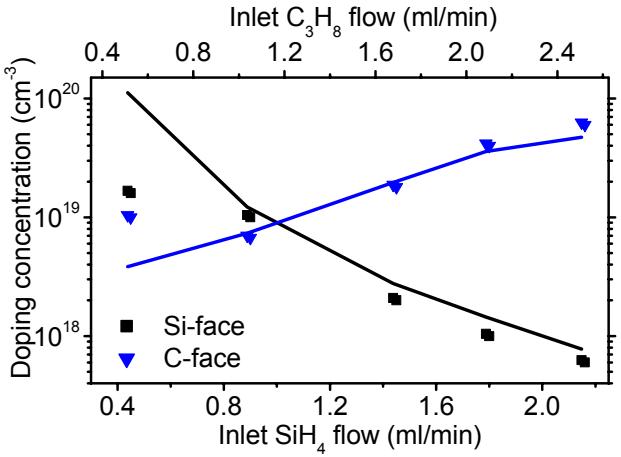


Growth Rate



N Doping

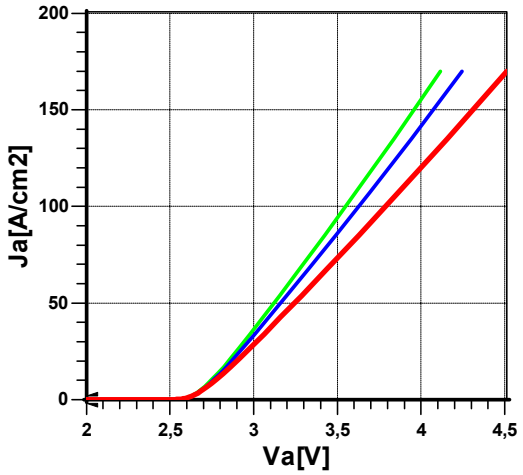




Degradation :

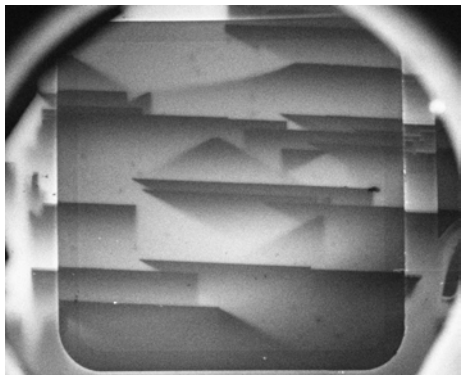
Drift of the forward current

Virgin device
Intermediate
Stressed

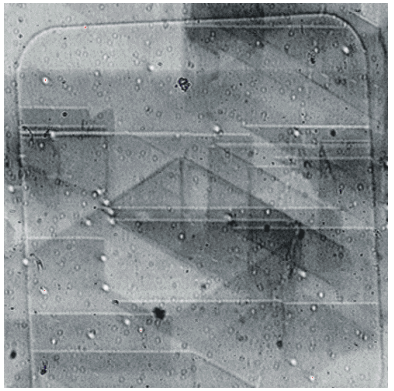


Creation and expansion of stacking faults

Cathodoluminescence
CL

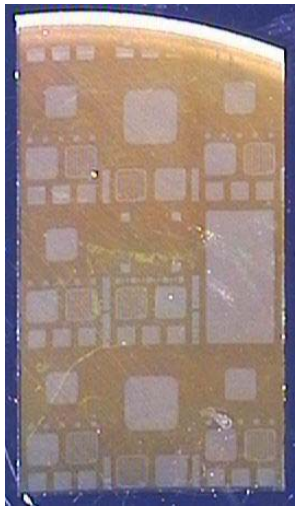


X-ray Topography

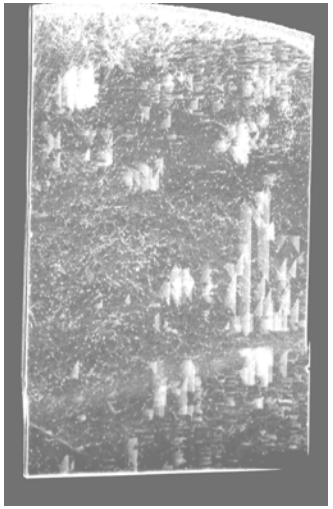


P. Bergman

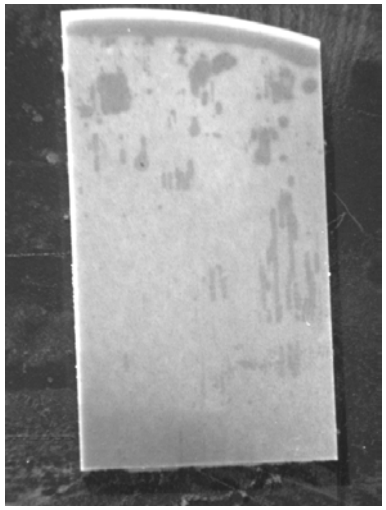
P. Bergman



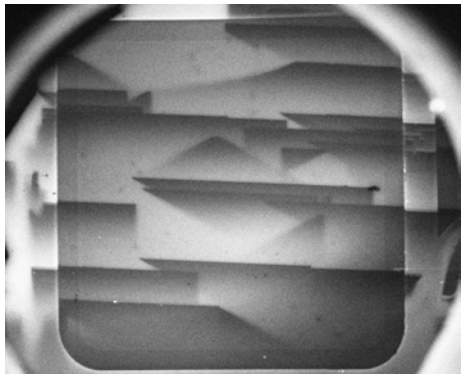
Lang topo [1,-1,10]



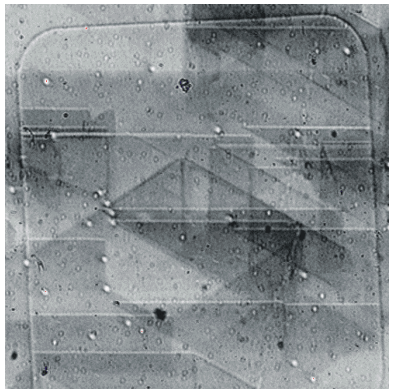
PL at 77K



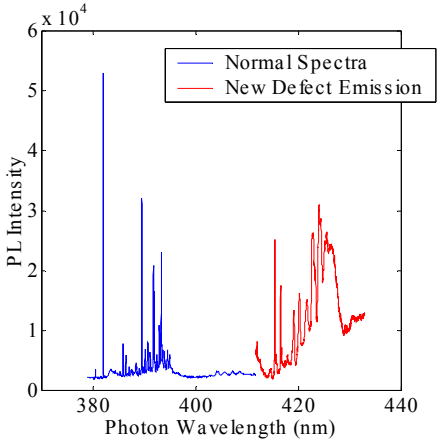
Cathodoluminescence
CL



X-ray Topography



Low Temperature PL



Today (2 inch diam)

Thickness typically 30-40 μm (80 μm)

Unif = σ/mean < 8%

Background doping level n-type (nitrogen) 1-2E14

N-doping 1E15 – 5E18 Unif < 20%

Al-doping 5E15 – 1E19 Unif <20%

Typical lifetime (35 um, 2E15) > 250 μs

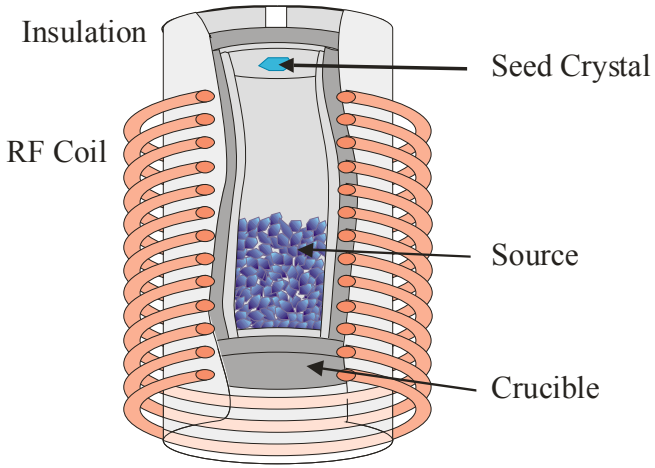
Future work related to SiC-CVD

- Degradation : reduction of critical defects
- Lifetime limiting defects
- growth on “non-standard” surface
- δ-doped layers
- Regrowth
- Other dopant : P, As, B, V…

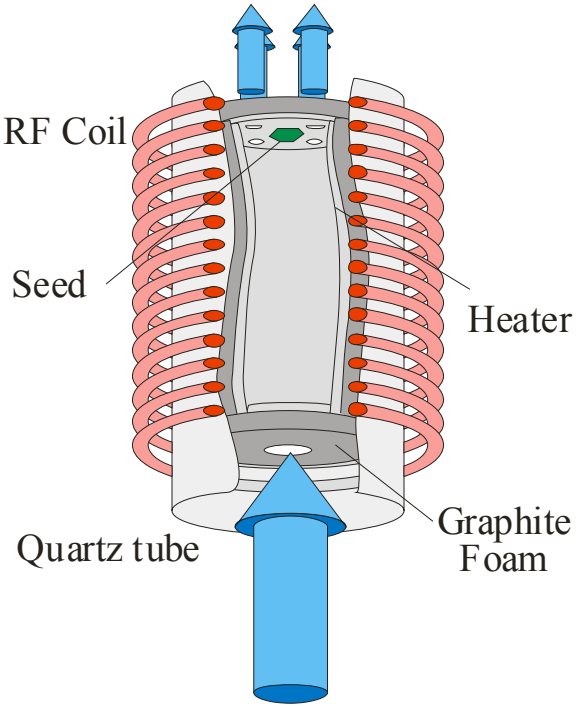
High Temperature CVD ⇒ Bulk

O. Kordina
A. Ellison

Seeded Sublimation Growth



T process:
2100 – 2300 C



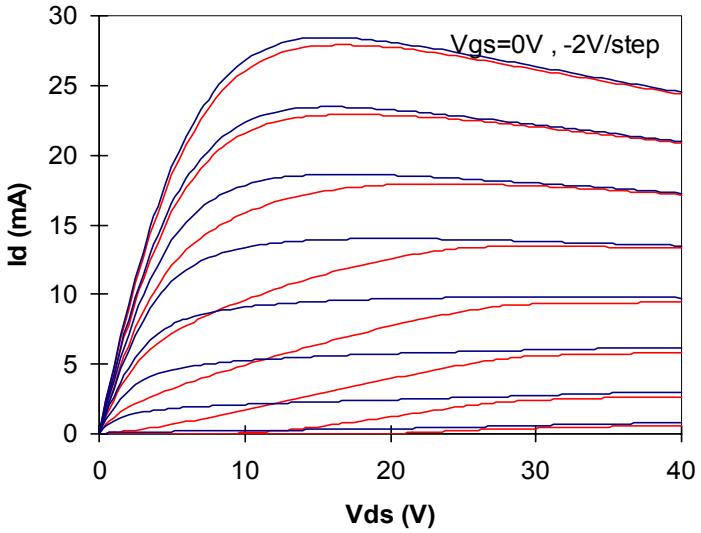
HTCVD advantages:
high vacuum
high purity of the sources gases
continuous supply of the source material
possibility to adjust C/Si

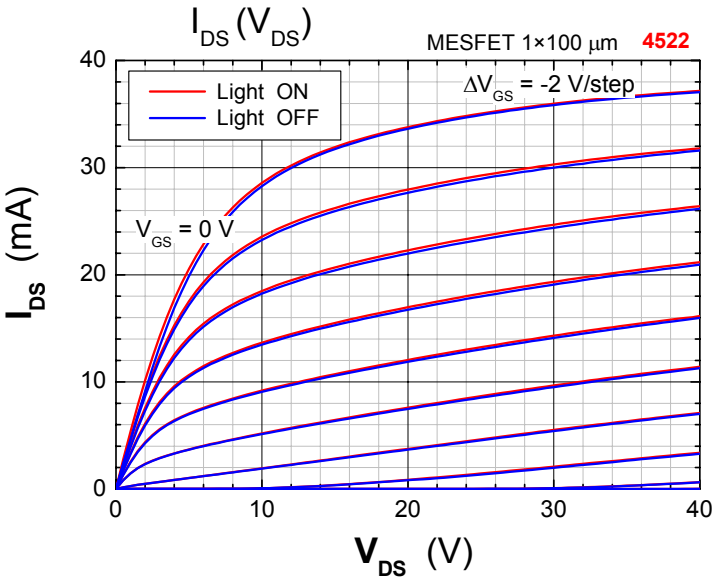
High Frequency Device

SiC MESFET with
Commercial S.I. substrate

SiC MESFET with
PURER SUBSTRATE
(HTCVD)
(80 V STRESS)

Degradation of I-V static characteristics





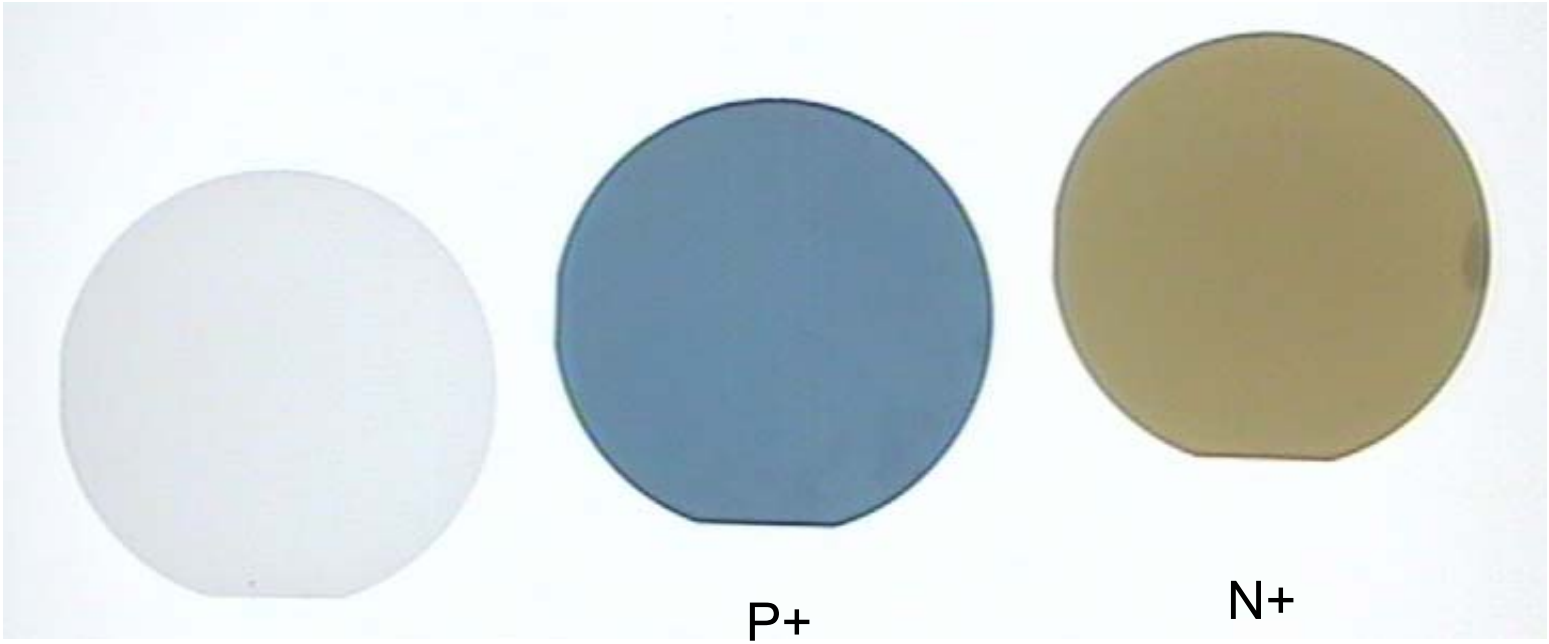
THOMSON-CSF
LABORATOIRE CENTRAL DE RECHERCHES

C. Brilinski

ECSCRM 2000 + JESICA PROJECT

OKMETIC
High Quality Silicon Wafers

2-inch diameter 4H-SiC substrates pilot products



SI
on- and off-axis

P+
off-axis

N+
off-axis

Future work related to HTCVD

Characterization :

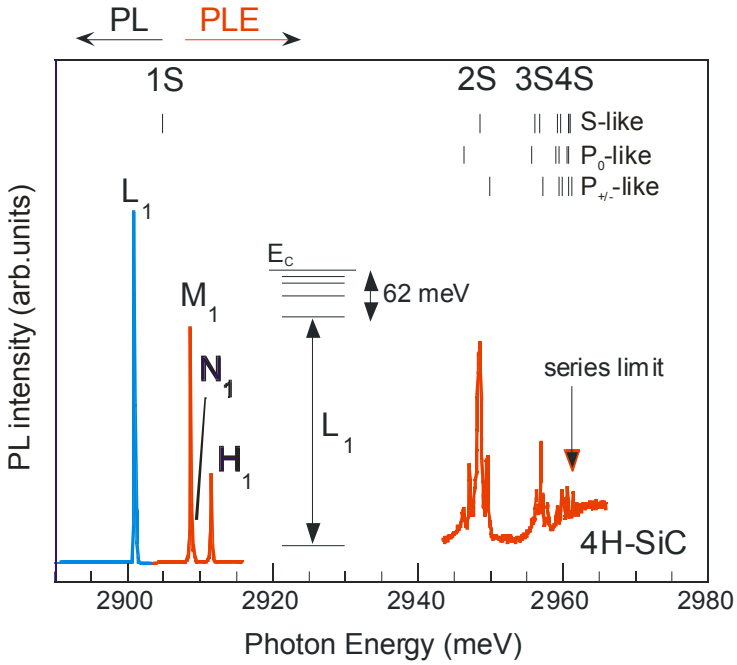
- identification of defects in SI SiC and understand their properties
- Support to Okmetic (SI, N and P substrates)

Characterization

Most studied defects in SiC after irradiation / implantation and annealing
(2 **MeV** – T>1200 C)

Optical

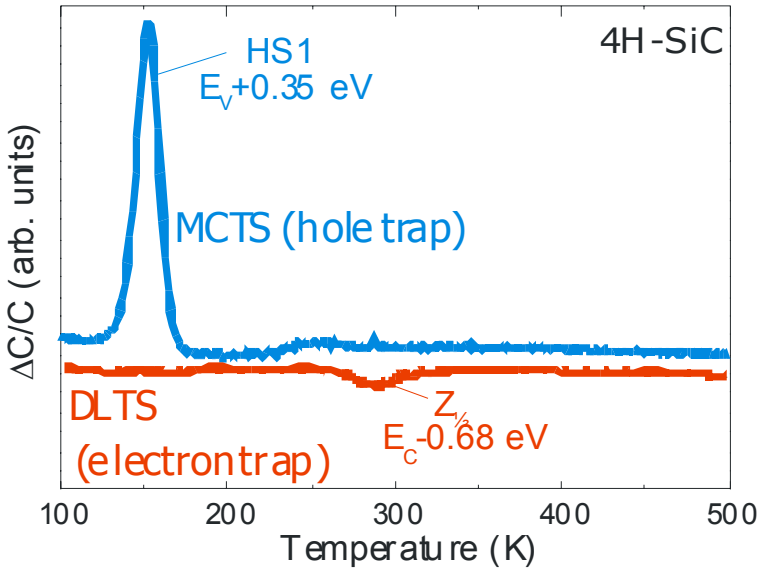
D_1 : Speudo-donor



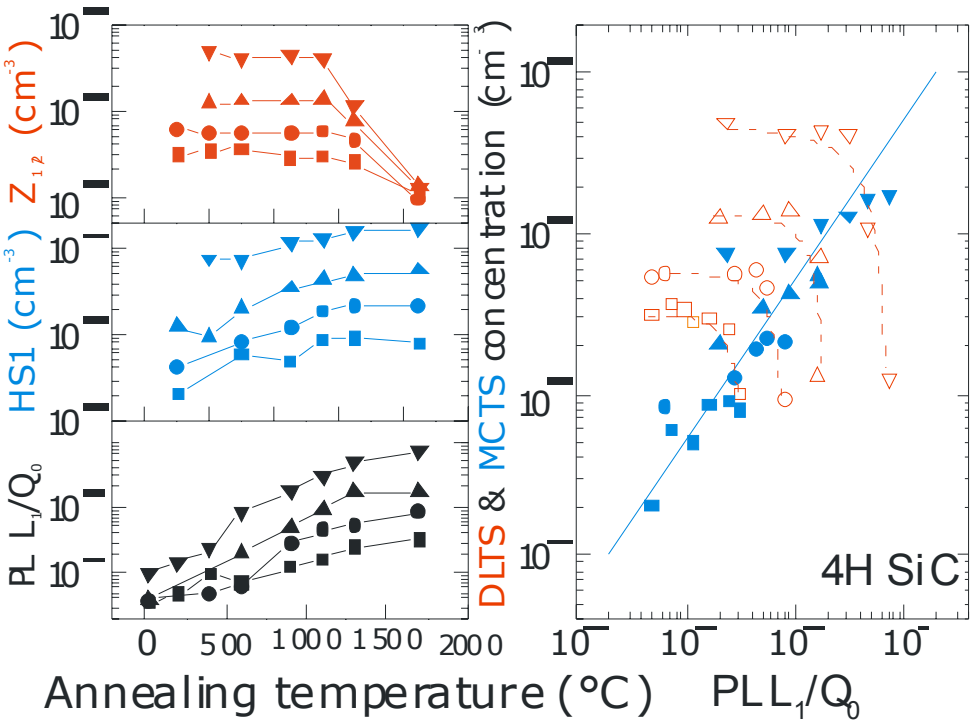
(T. Egilsson)

Electrical

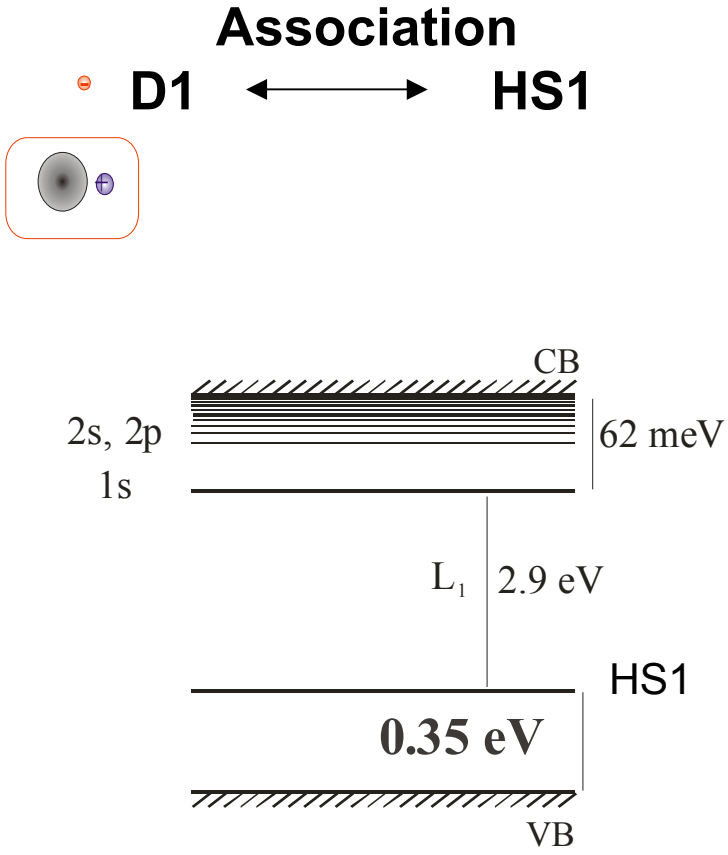
$Z_{1,2}$



(L. Storasta)


PL L_1/Q_0
HS1 (cm^{-3})
$Z_{1/2}$ (cm^{-3})
DLTS & MCTS concentration (cm^{-3})
4H SiC
0
500
1000
1500
2000
Annealing temperature (°C)
PL L_1/Q_0

(L. Storasta)


Association
D1
HS1
CB
2s, 2p
1s
62 meV
L_1
2.9 eV
HS1
0.35 eV
VB

Characterization

Defect study : Atom displacement

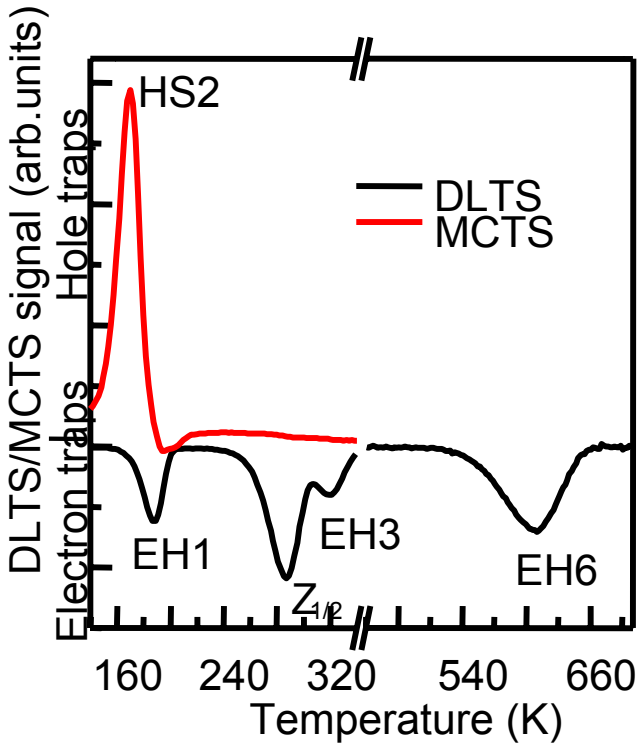
C : 90 keV

Si: 220 keV

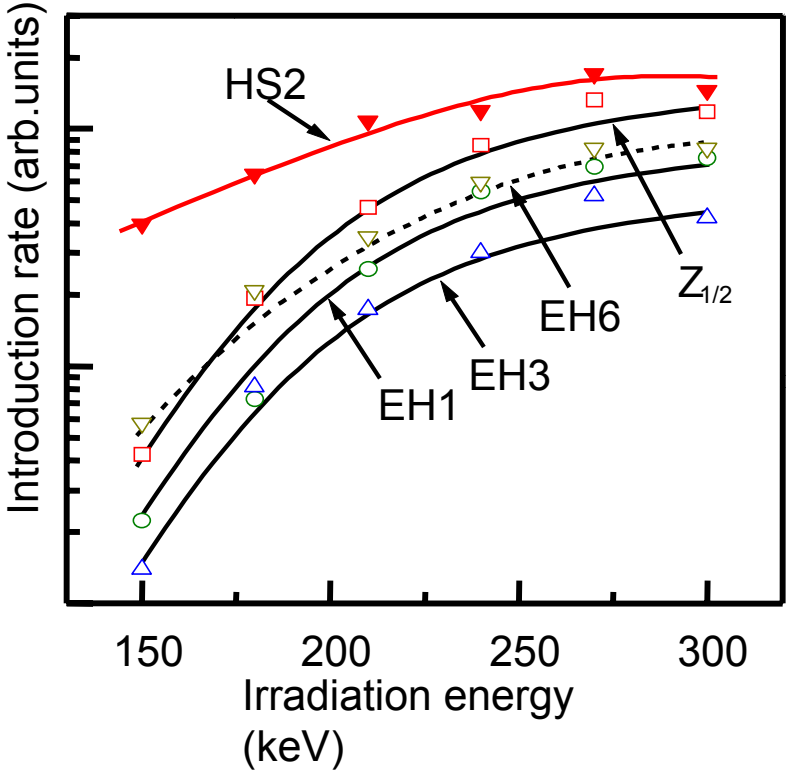
Face dependent ?

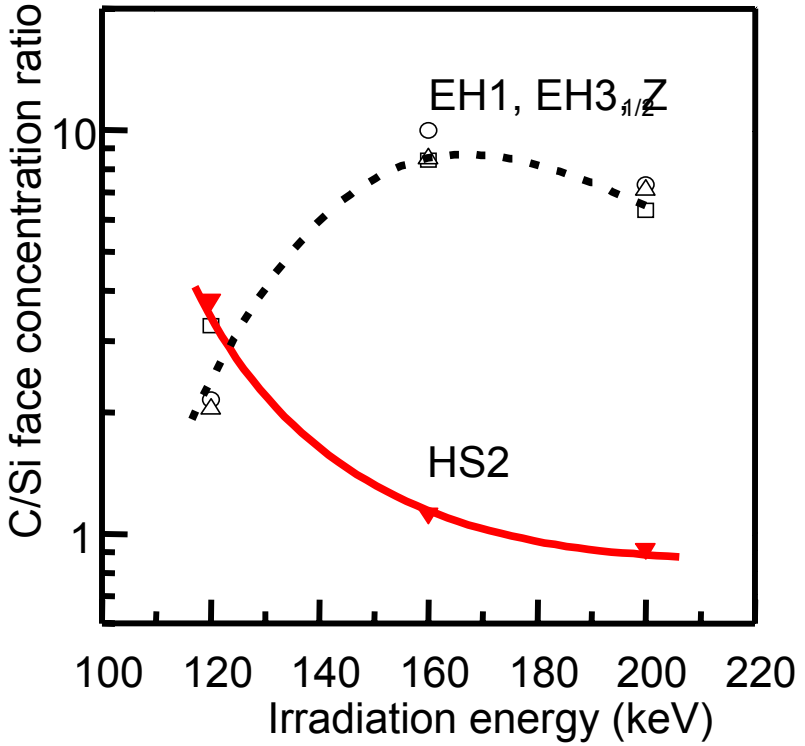
N-type 2.5E15 cm^{-3} epi
Low energy electron irradiation
80-300 **keV**

L. Storatas



Si-face 4H epilayer





C related centers

L. Storatas

F. Carlsson

- Photoluminescence