The homo-epitaxial growth of thick single crystal CVD diamond for detector applications

N. Tranchant*, P. Bergonzo & M. Nesladek, Darmstadt 2005

Introduction

Substrate pre-treatment

MW PECVD growth parameters

Time Of Flight

Raman

Conclusions

Pre-treatments

Substrate :

High Pressure High Temperature
Size : 3 x 3 x 0.5 mm
Sizes available up to 10 x 10 mm
Orientation (100)

Stripping :

H_2SO_4 + KNO_3 + Heating
(surface oxidation)

Ultrasonic bath DI H_20

Microscope

HPHT substrates Sumitomo
Rms ~ 2-3 nm (AFM)

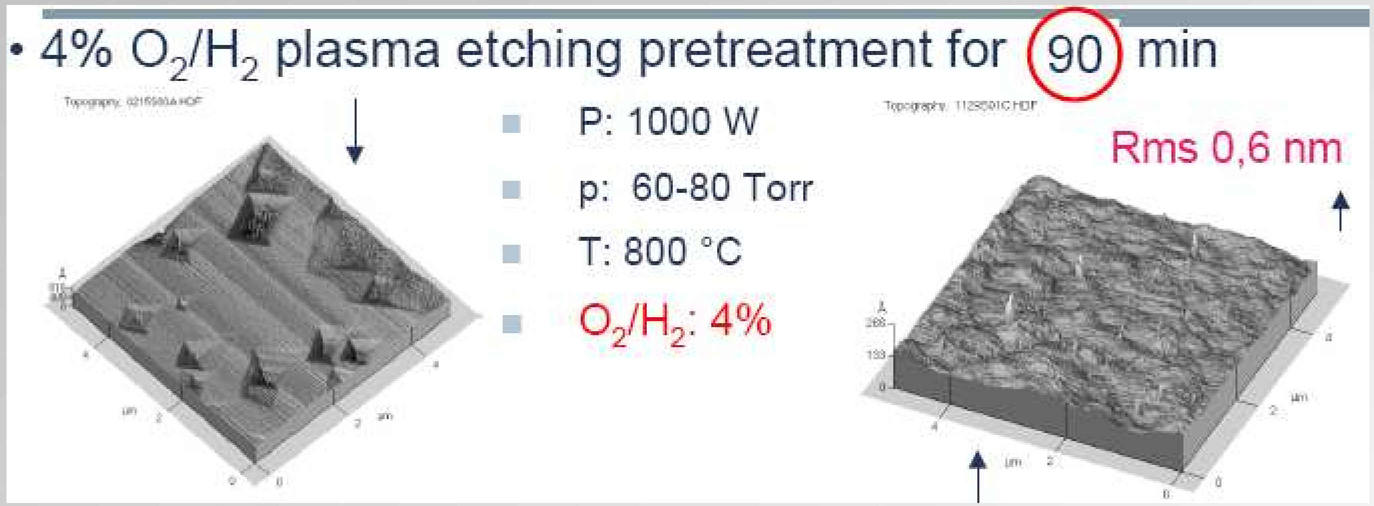
Growth

Plasma enhanced CVD AsTex PDS 17 MW reactor

Aim:
optimization of growth conditions to obtain high quality layers

CH_4 concentration
Temperature
Pressure
MW Power

Plasma etching



Surface quality important
to reduce the occurrence
of hillocks and unepitaxial crystallites

Etching :

Power = 1000-3W
Pressure = 70Torr
Gas : H_2 = 96%, O_2 = 4%
Time = 60-90 minutes
Temperature = 930℃

Anisotropic Plasma etching removes the surface defects (polishing etc.) and leaves smooth (100) surfaces with atomic steps , **Rms : 3 nm - 0.6 nm**

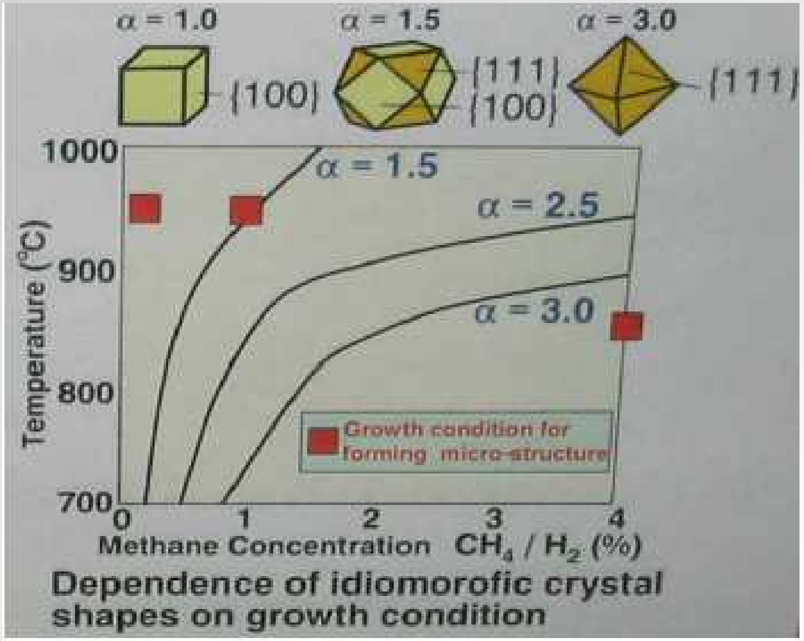
See for details Growth and characterization of near-atomically flat, thick homoepitaxial CVD diamond films
G. Bogdan et al, Physica Status Solidi, 202 (2005),2066

Growth parameters

Optimization of growth parameters to obtain right alpha parameter for growth of (100) films

High growth rate

	H_2	CH_4
Rate (sccm)	460	30
Percentage (%)	93	7

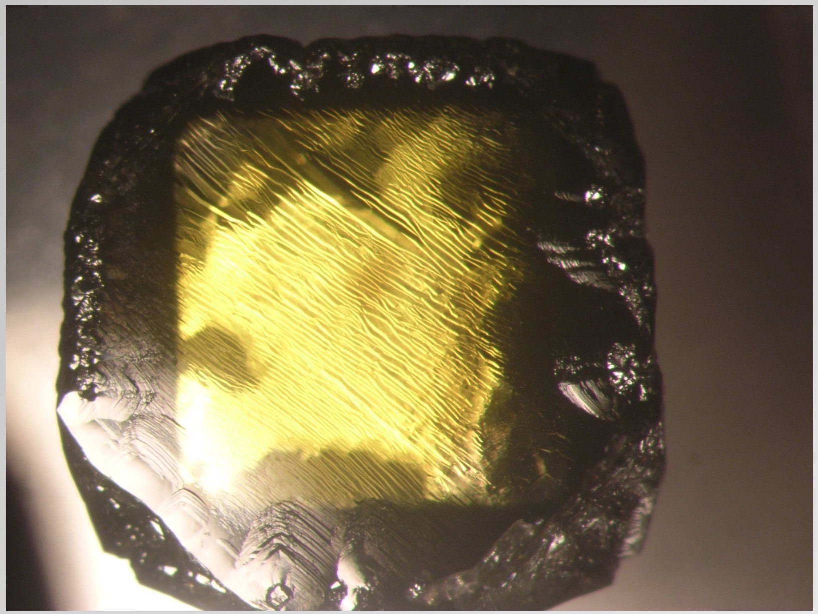


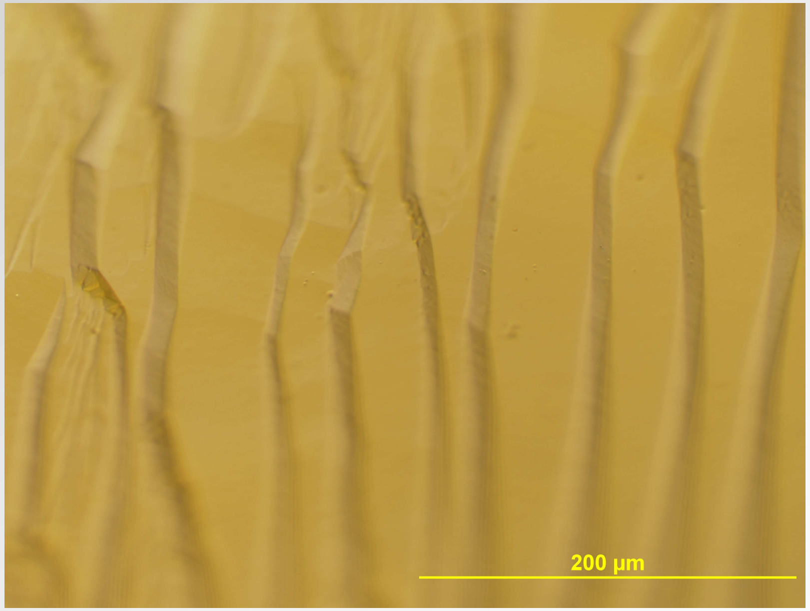
Alpha Parameter determines the structure and morphology of the films.

Time (Hours)	100
Velocity (µm/H)	11
Thickness (mm)	1-1.5

Power (W)	Pressure (Torr)	Temp (℃)
560	180	860 – 900

Sample



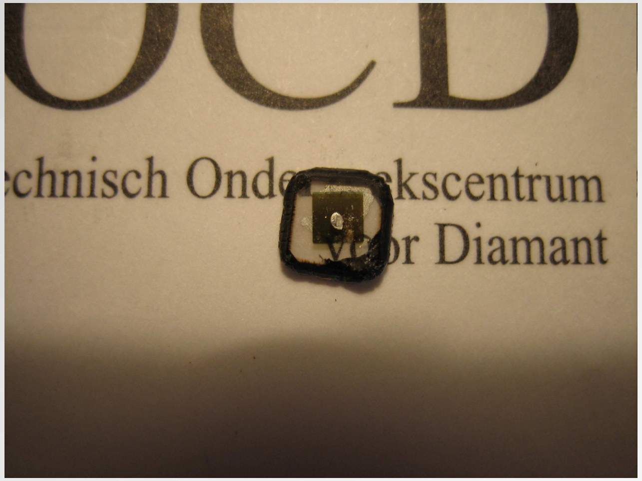


Result of step flow after 1 mm film growth

⇒Steps height ≈ 20µm
⇒No pyramidal hillocks

Growth of 1-1.5 mm thick, flat CVD diamond films

Fabrication of free standing films



Laser cutting (WTOCD Belgium)

Polishing

Free standing CVD diamond plates 5X5 mm^2

Characterization : TOF, Spectroscopy

Time Of Flight (TOF)

Information on :

Drift mobility

Internal electric field

Transit time of charge cloud induced by alpha particles

Time Of Flight (TOF)

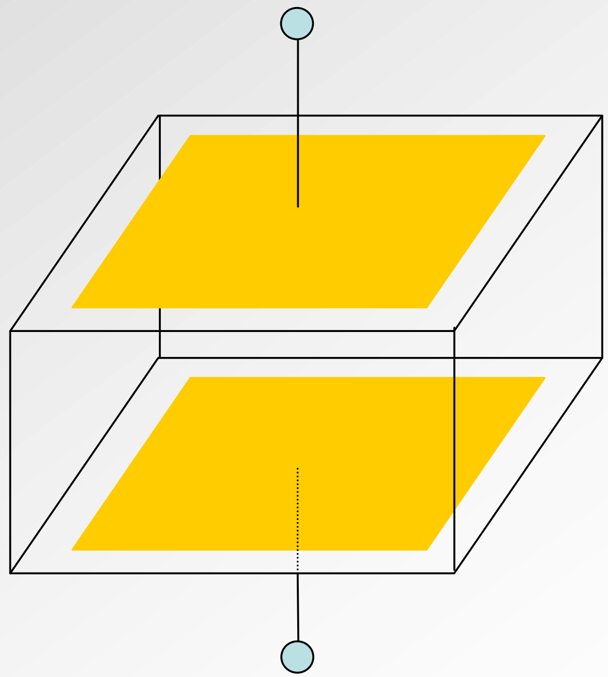
Plating

Electron Beam Bombardment
(oxidized surface)

Nickel \ Gold

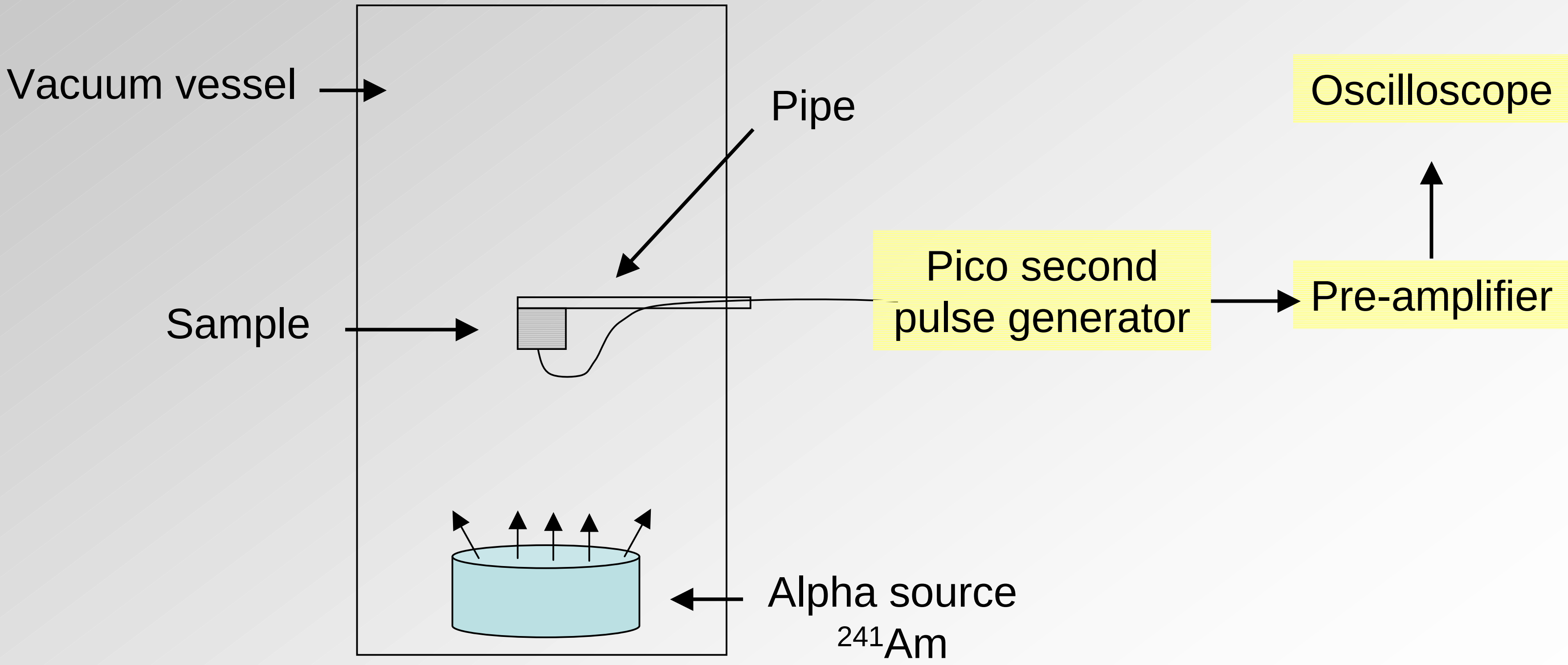
Rate : 0.12nm/s

Thickness : 20 nm

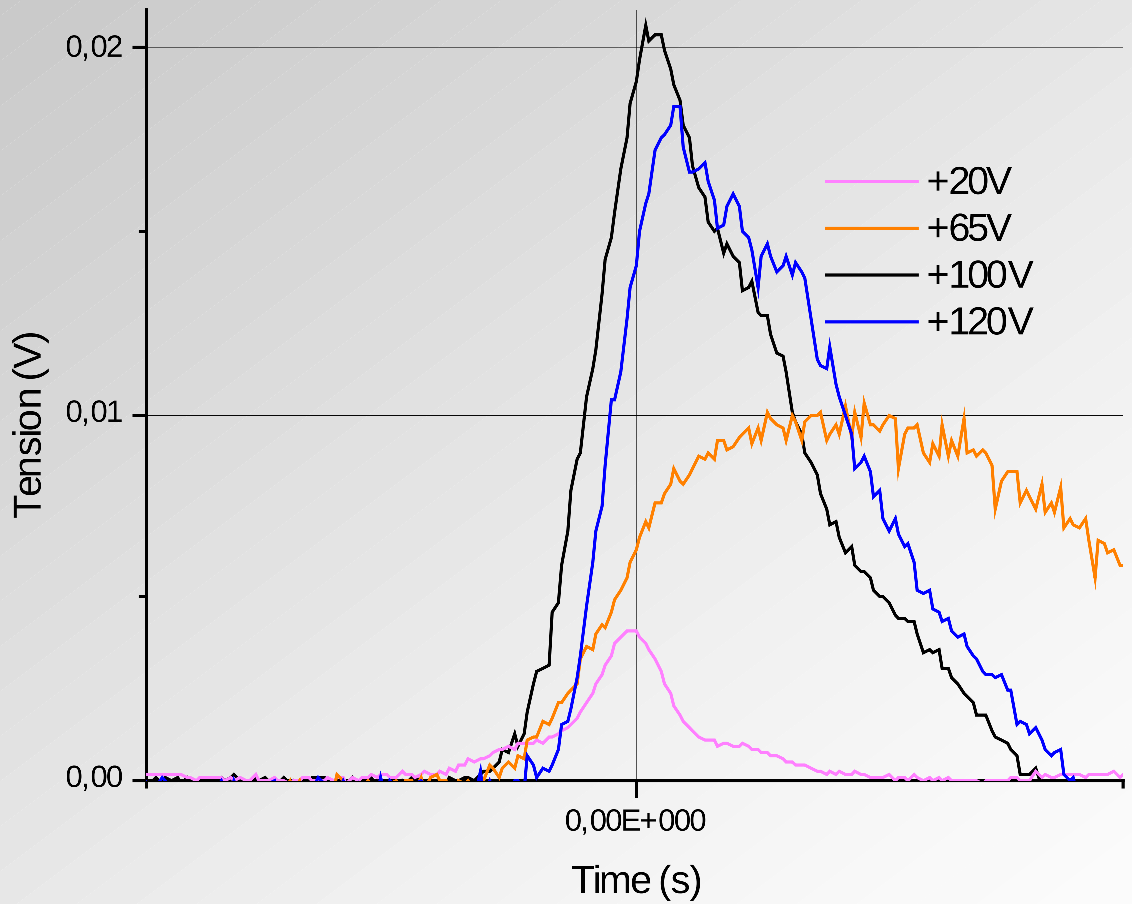


Time Of Flight (TOF)

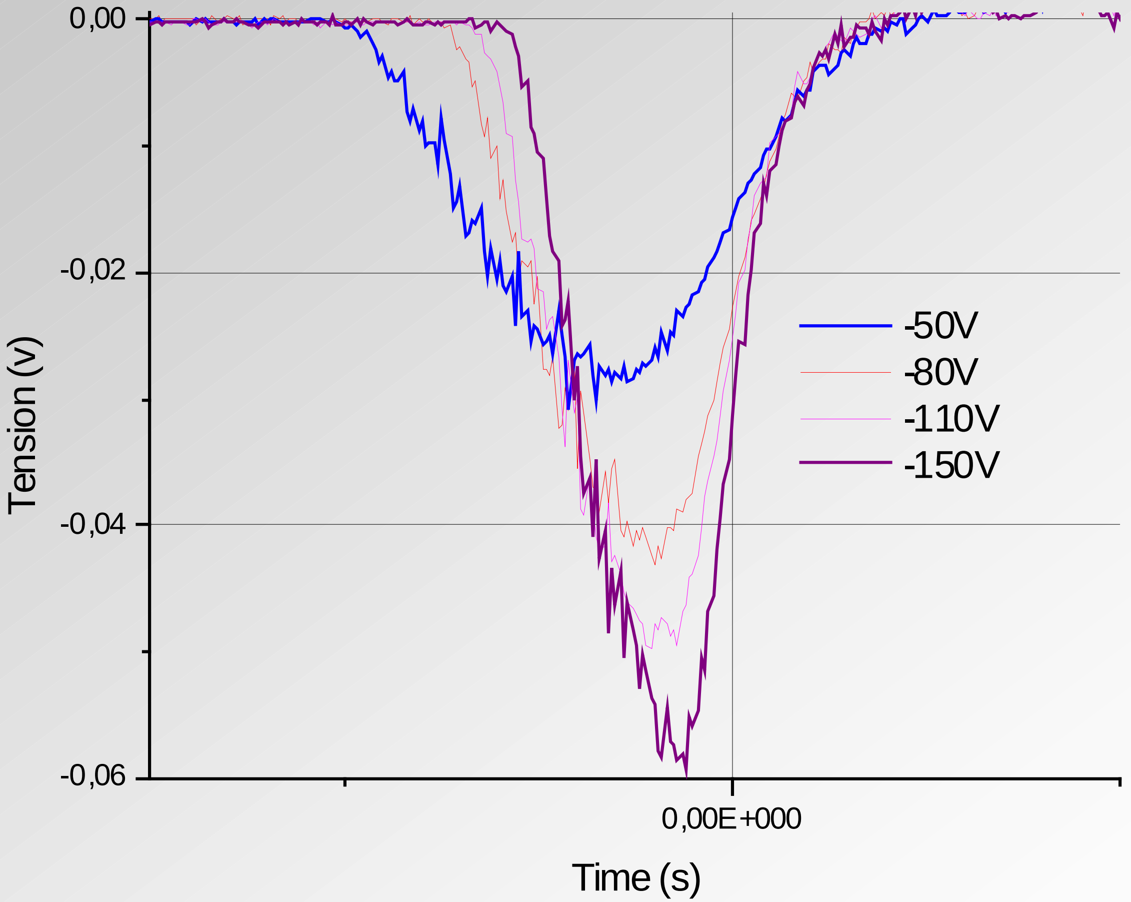
Experiment



TOF for electrons



TOF for Holes



Time Of Flight (TOF)

Results

Transit time for electrons and holes (100V)

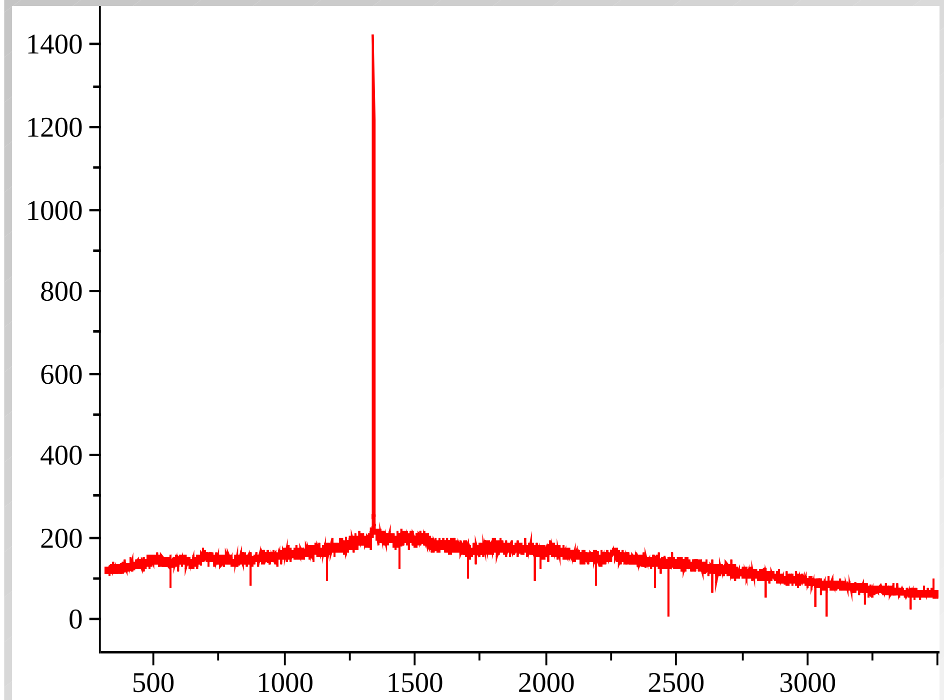
t_C = 2. – 2.7 ns

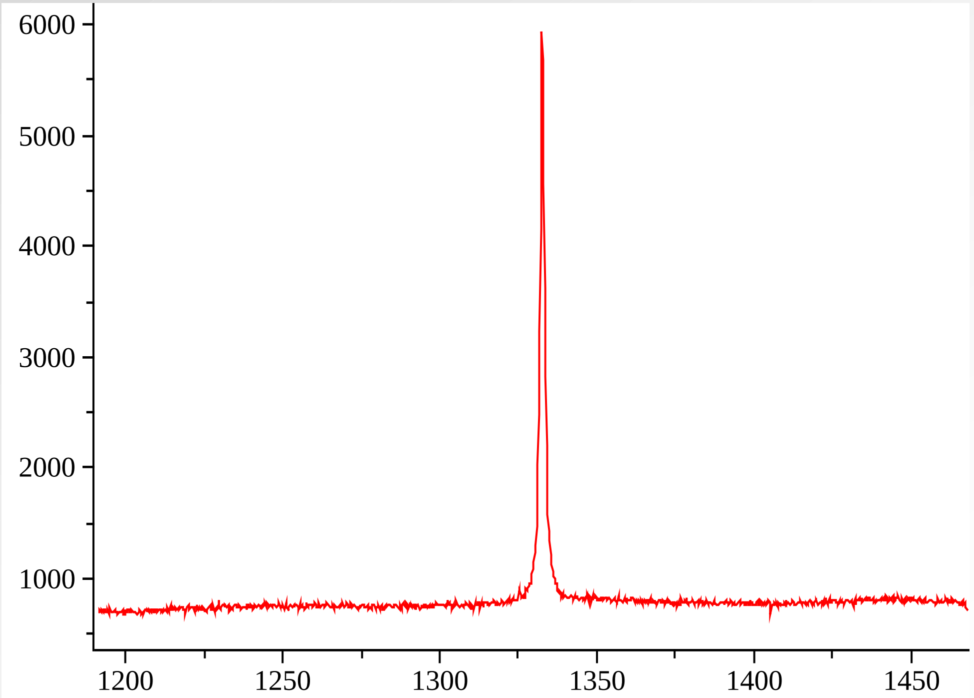
⇒Drift velocity : v_{drift} = 85 µm/ns

⇒Mobility : μ = 1800- 2500 $cm^2/V.s$

Raman spectroscopy

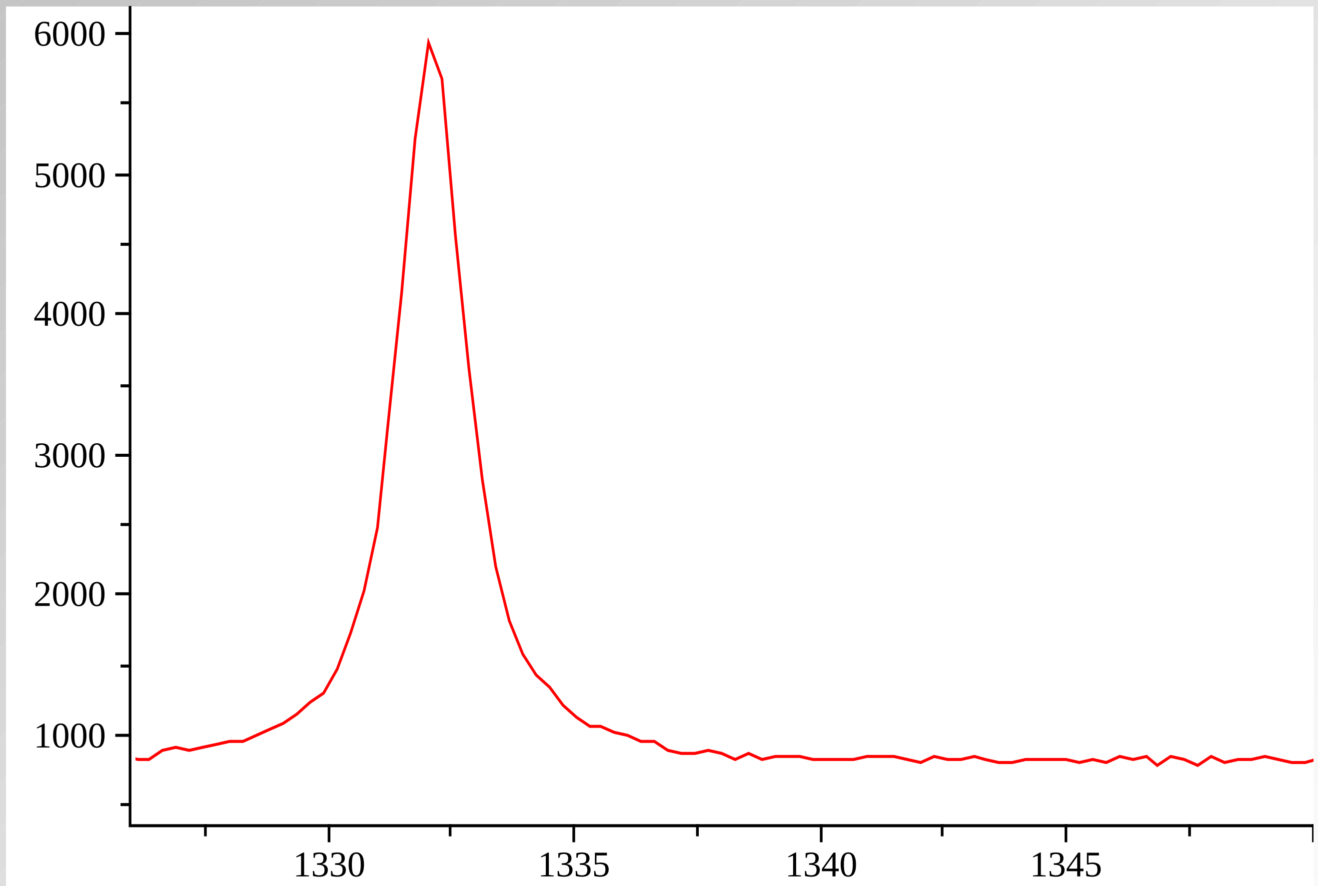
Homo-epitaxial layer





sp3 signature only : cubic diamond

Raman spectroscopy



Peak : 1332 cm^{-1}

Bandwidth : 1.6 cm^{-1}

=> No stress

Next planning

Raman spectrometry on the substrate layer

Infrared spectrometry on homo-epitaxial layer (FTIR)

Optimization of the growth conditions

Studies on the growth parameter (α)