Homo-epitaxial growth and characterization progress in Saclay

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Agenda

• Motivation
• Growth parameters
• Results
• Raman’s spectroscopy
• Diamond View & FTIR
• TOF & CCE
• X-ray’s measurement
### Motivation

**Why diamond?**
- Radiation’s hard
- Fast detector $\rightarrow$ high mobility
- High collection efficiency

<table>
<thead>
<tr>
<th>Material</th>
<th>Availability, size</th>
<th>Lattice parameter</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3C-SiC</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Ir</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>HPHT</td>
<td>+</td>
<td>-</td>
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</table>

**Availability, price**
Growth Parameters

HPHT’s preparation

Chemistry attack:
→ boiling acid
→ rinsing

Plasma etching:
$\text{H}_2/\text{O}_2 (4\%)$
μ-wave power 1kW
Set period 1h

Growth Parameters

- MW power → from 500 to 800W
- Gas Pressure → from 160 to 300 mBar
- Temperature → roughly 920°C
- CH4 (%) → from 2 to 10%
In situ characterizations

OES

Gas analysis

No nitrogen detected in the chamber

Influence of the methane concentration

Plasma temperature (°K)

Methane concentration (%)

Gas analyser

Leak valve

Mass spectroscopy

Second vacuum stage

Primary root

REACTOR
Laser cutting & polishing

After growth

After polishing
Different morphology according to the experimental setup:

- **Rough surface**
- **Terraces**
- **Control growth mechanism**
- **Flat surface**
- **Lower growth rate**
Effects of the CH$_4$ concentration on the surface roughness

New experiments applying more drastic conditions (340 mBar; 700W) show higher growth rate (20 µm/h) & still a good morphology
Raman’s spectroscopy

Confocal Raman → Laser excitation = 514.32 nm

Measured peak

Fitted peak

Peak: 1332 cm\(^{-1}\)

FWHM: 1.6 cm\(^{-1}\)

⇒ No internal stress

⇒ Only diamond bounds
Raman’s mapping

Confocal Raman → Laser excitation = 514.32 nm

![Image of Raman mapping with peak position and FWHM scales.]
Diamond View

# A040506

UV-light

N-vacancies in red

N-interstitials in green

Day-light

# A310605
Increasing CH$_4$ vs. Increasing the pressure

[Graph showing absorbance vs. wavenumber for different pressures and CH$_4$ concentrations]
Taking 3000 cm\(^{-1}\) as absorbance coefficient for diamond:

we have a content of about \(10^{19} \text{ cm}^3\) C-H bounds in this sample!

\[ A = \alpha \times d \]
Time Of Flight: $^{241}\text{Am}$

High mobility:

$\mu_e = 3838 \text{ cm}^2/\text{V.S}$

$\mu_h = 1468 \text{ cm}^2/\text{V.S}$

Reproducible measurements
Current Charge Efficiency

$E = 0.4 \text{ V/µm}$

$\text{CCE} = 98.6\%$

$\Delta E/E = 1.9\%$
X-ray’s measurement

Dose rate: 12 Gy/h

→ Linear response to the doses for both electrons and holes

→ Reproducible measurements
Perspective

➢ Do FTPS measurements on our samples

➢ Design a new holder’s shape

➢ Try other contacts on diamond

➢ Set up other growth conditions
Thanks for your attention !!!