LPSC Grenoble

Laboratoire de Physique Subatomique et de Cosmologie

Formation of vibrationally-excited H_2 on graphite surfaces

(comparison with tantalum and stainless steel surfaces)

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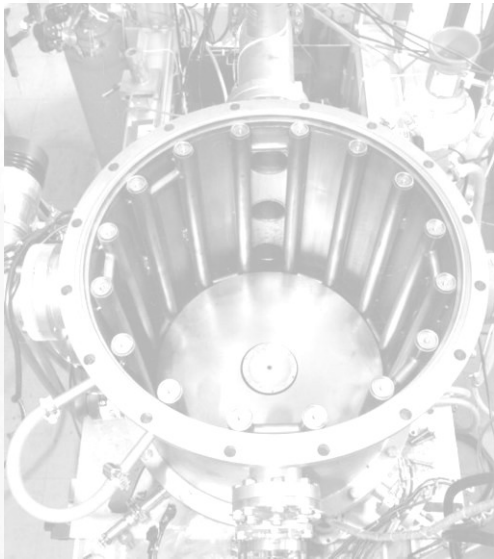

Outline

1/ Overview of the work
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- Experimental tasks

2/ Experimental set-up and diagnostics
- Camembert III ion source
- Laser-induced photodetachment and electrostatic probes

3/ Results
- Optical emission spectroscopy (OES)
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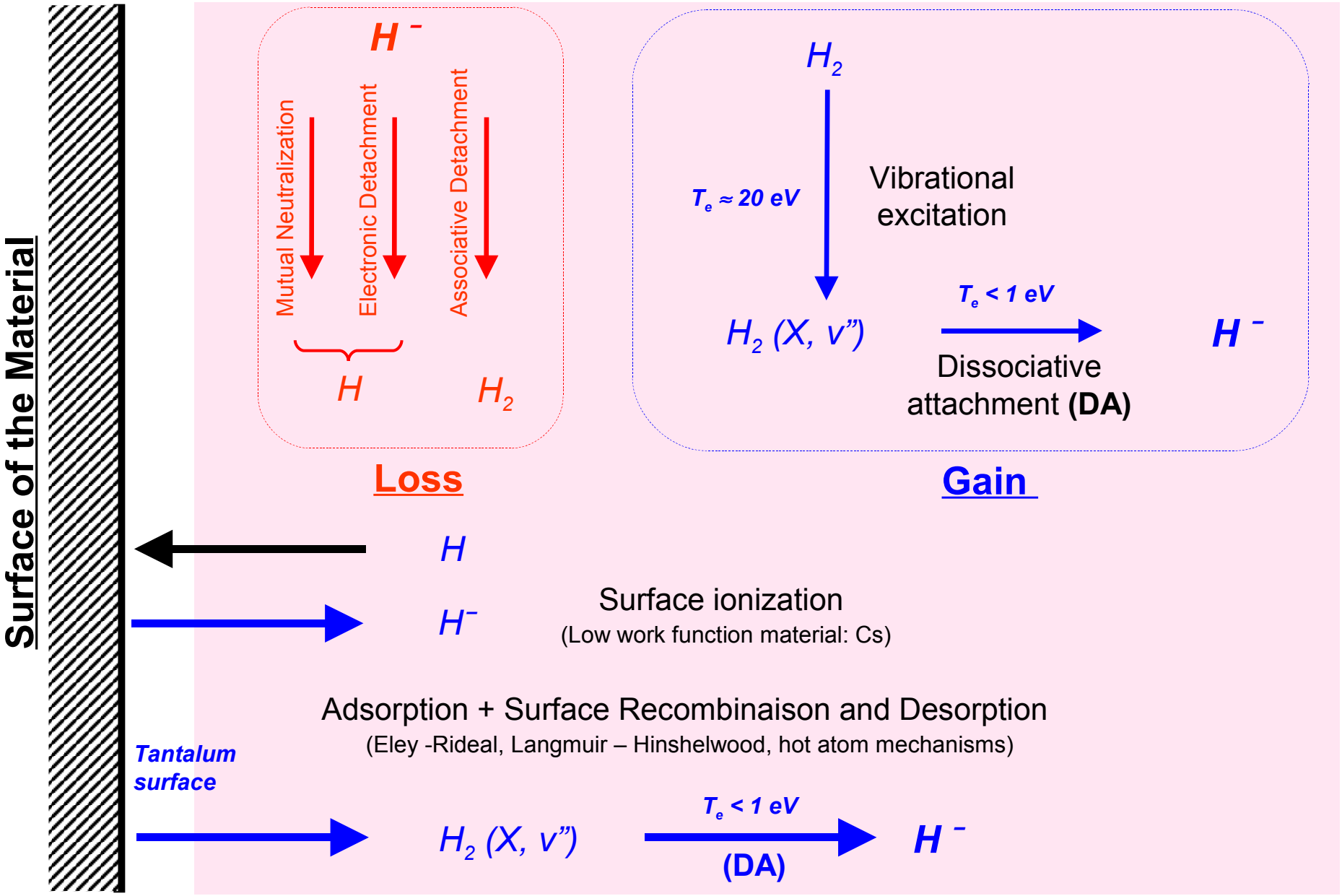
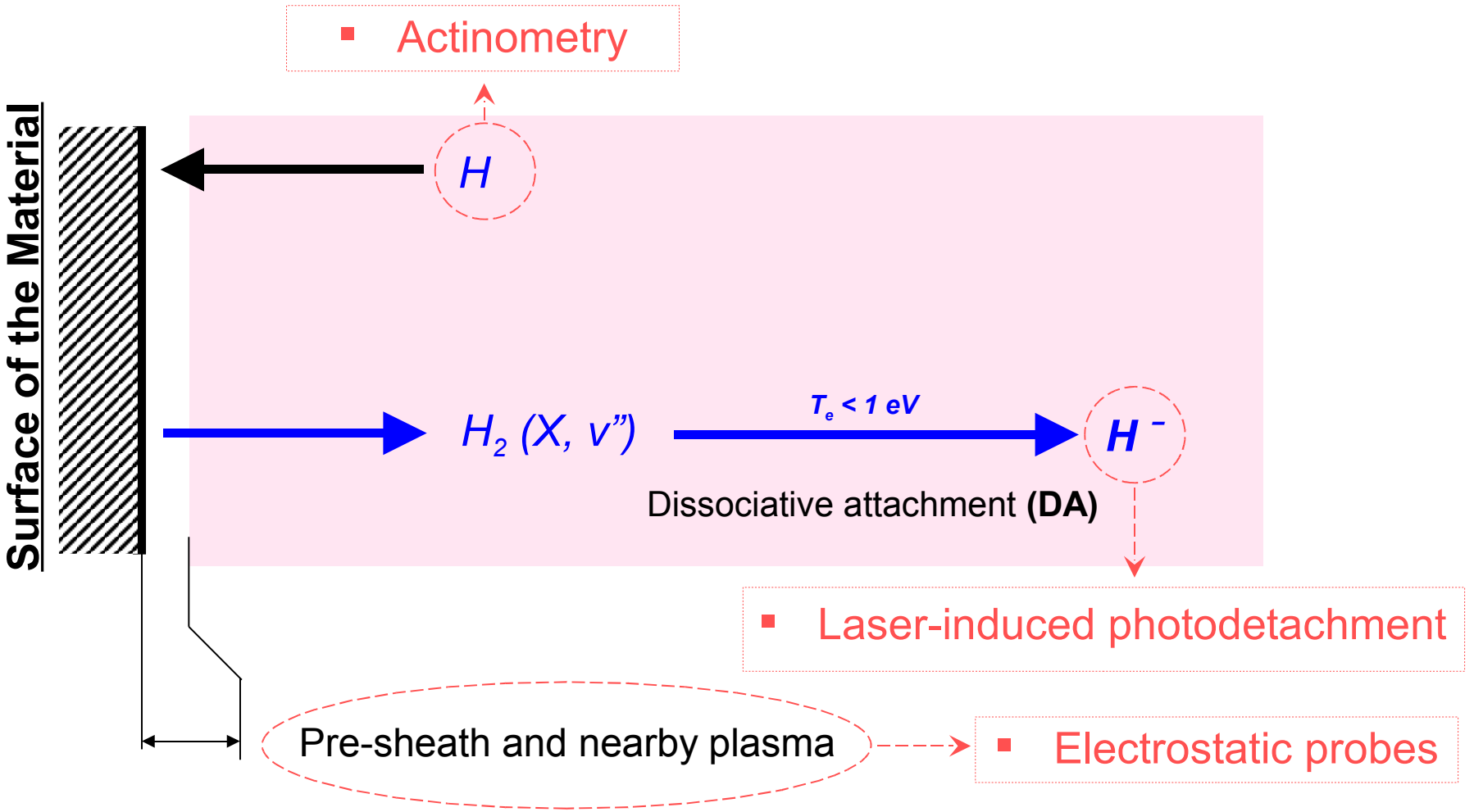
- Laser photodetachment & Langmuir probe
  - Floating regime
  - Positively biased regime

4/ Conclusions

1/ Hydrogen plasma mechanisms

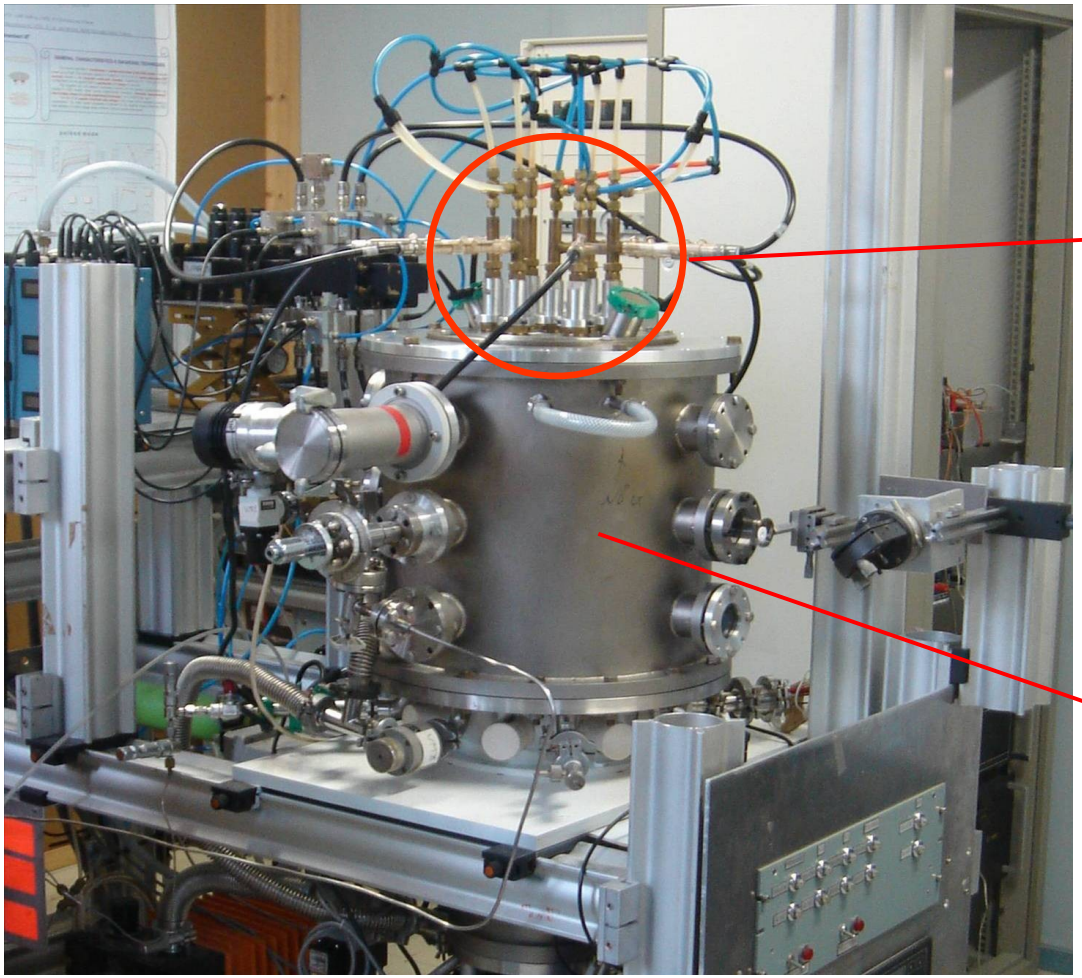


Experimental tasks

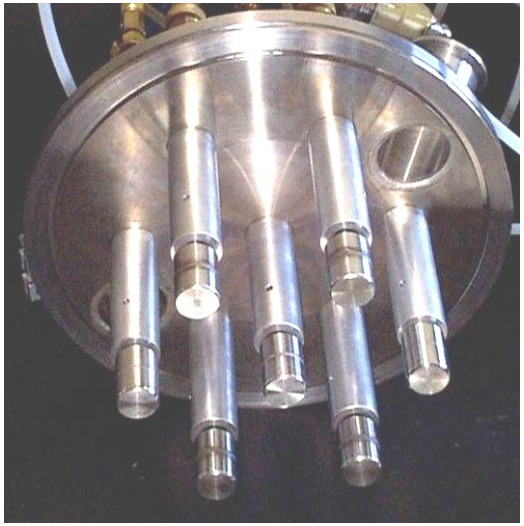


2/ Experimental set-up

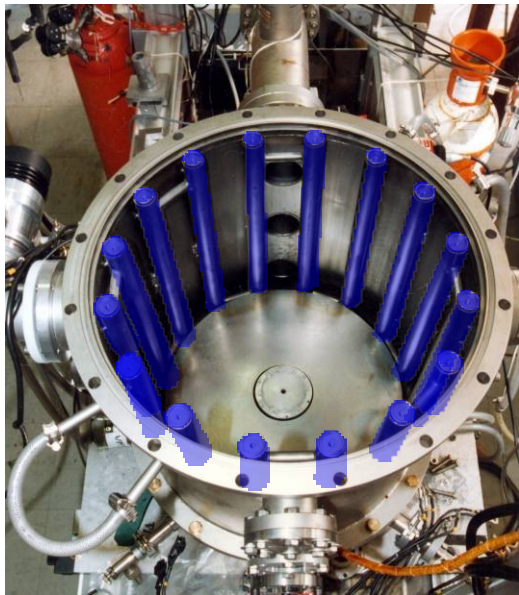
Dipolar microwave (@ 2.45 GHz) plasma sources (× 7)



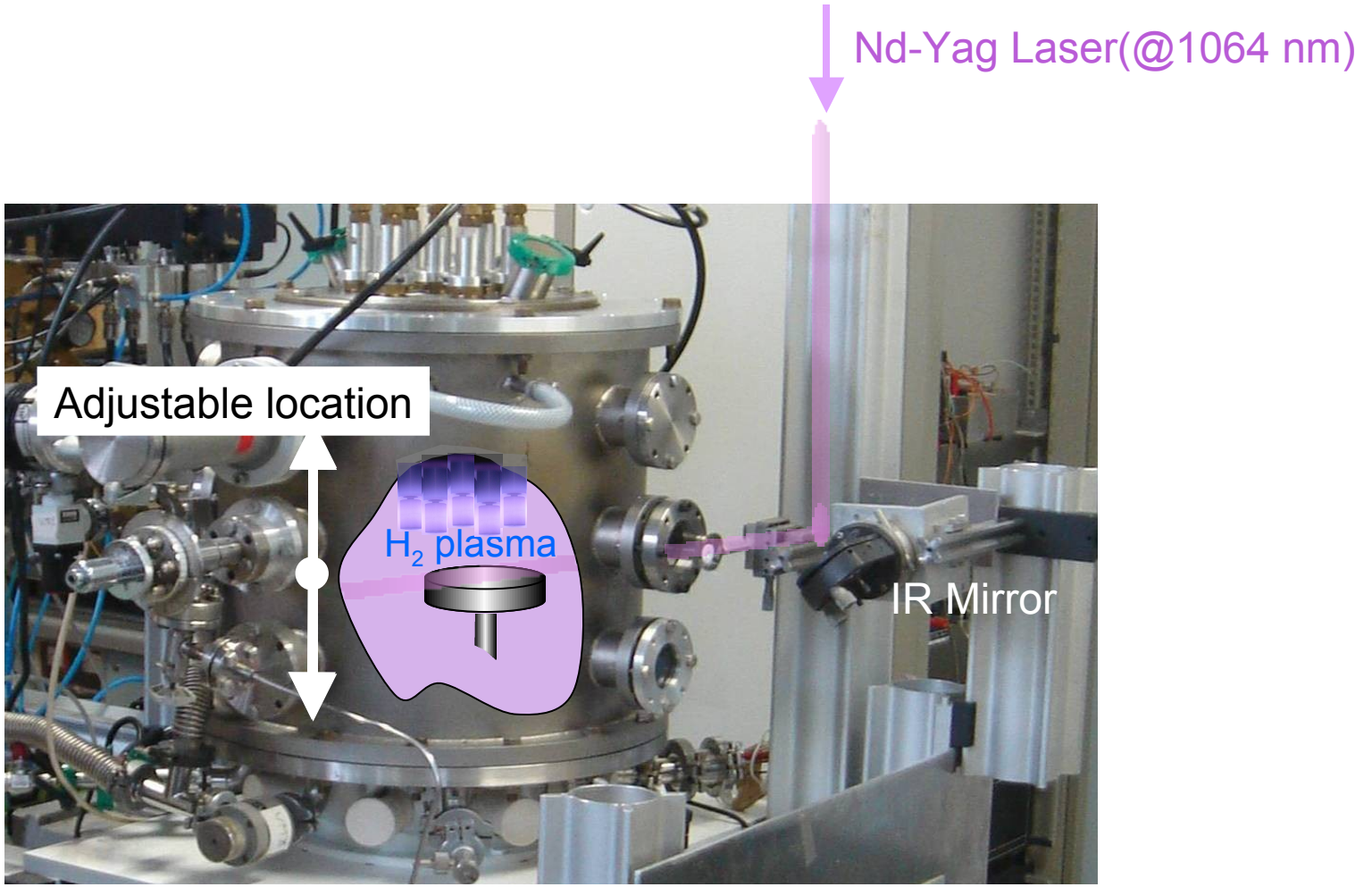
140 W (× 7)



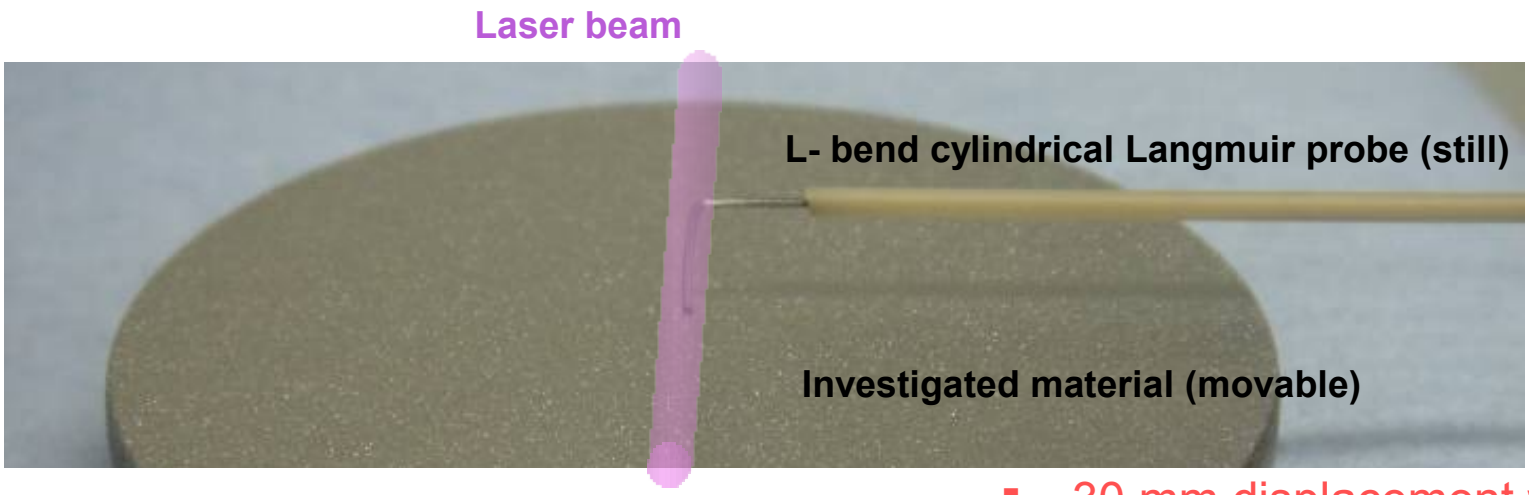
Magnetic shield

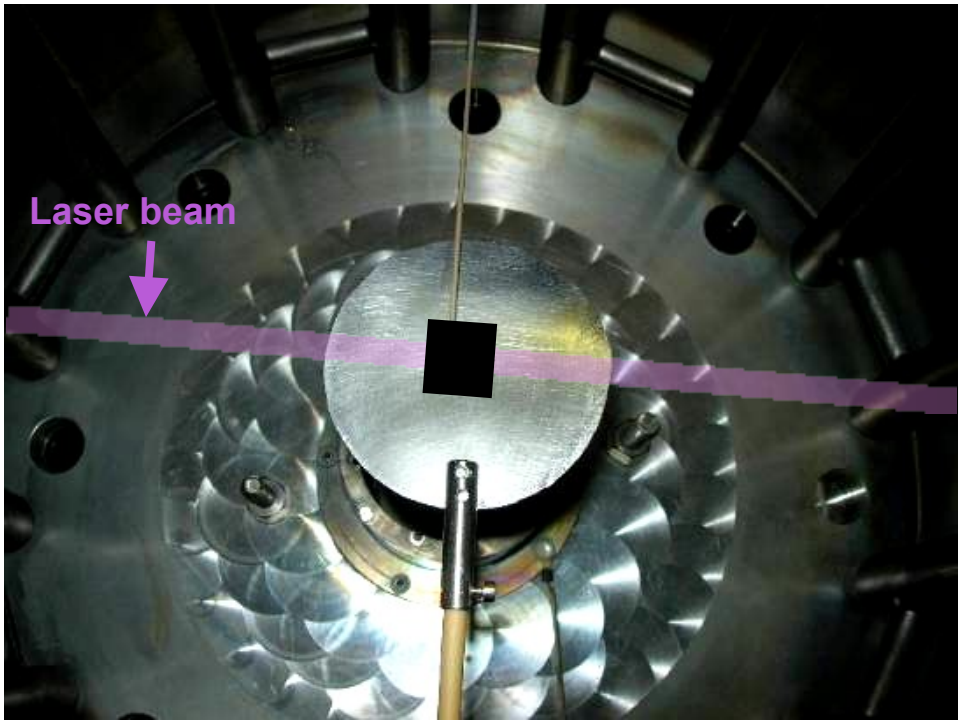


Photodetachment diagnostic



Photodetachment and LP diagnostics





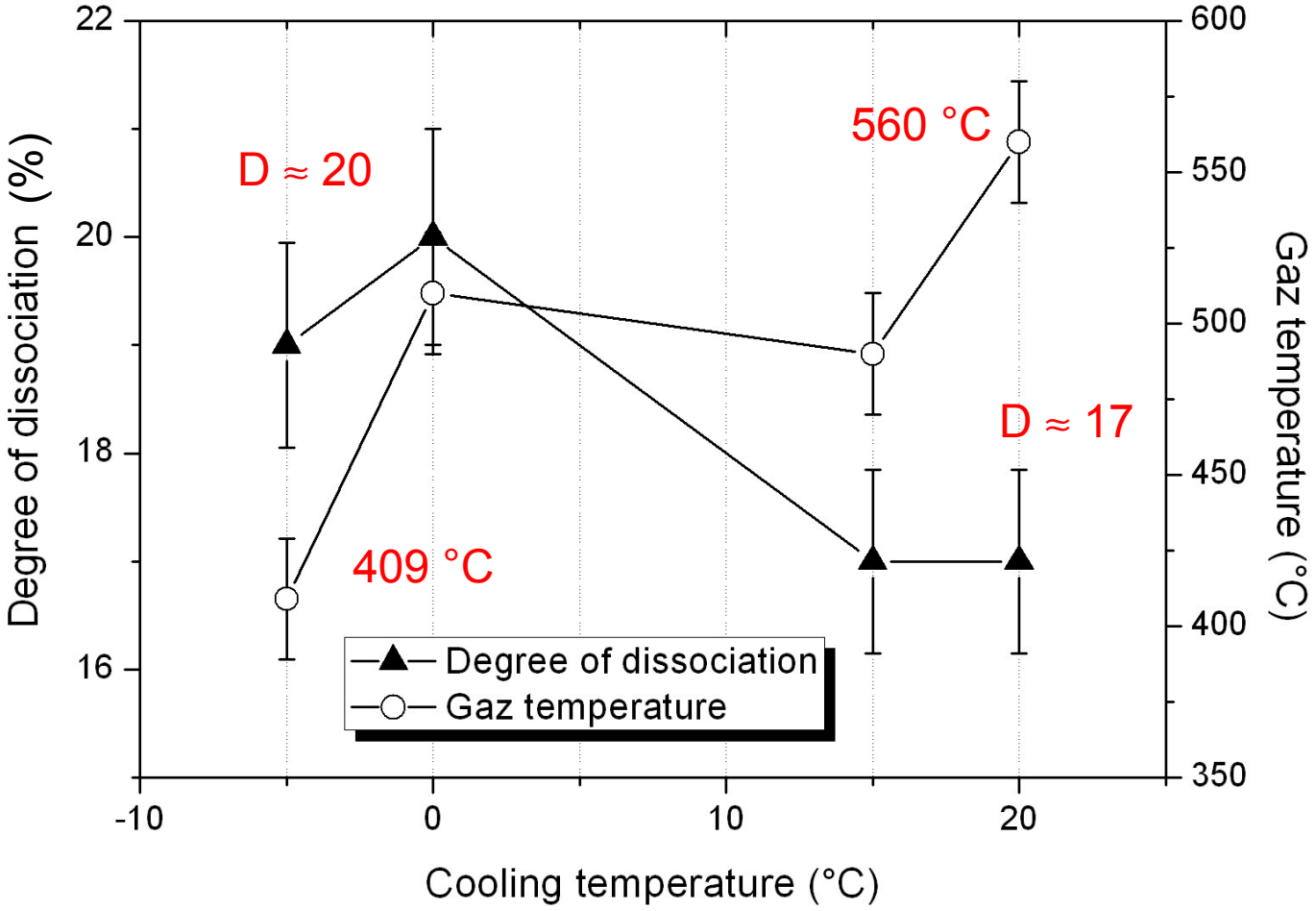
- 30 mm displacement width to investigate the surface vicinity.
- Samples:
  - disc, Ø 70 mm (Raw graphite, Ta)
  - square, 10 × 10 mm (HOPG)
- Laser beam:
  - 0.093 J/cm² (@ 1064 nm),
  - Ø 9 mm
- L-bend Langmuir probe:
  - Ø 0.5 mm, l ≈ 17 mm
- Emissive probe

3/ Results of OES measurements

$$D = \frac{[H]}{2[H_2] + [H]} = \frac{[H]/[H_2]}{([H]/[H_2]) + 2}$$

$[H] / [H_2] \approx 50\ \%$

$[H] / [H_2] \approx 40\ \%$

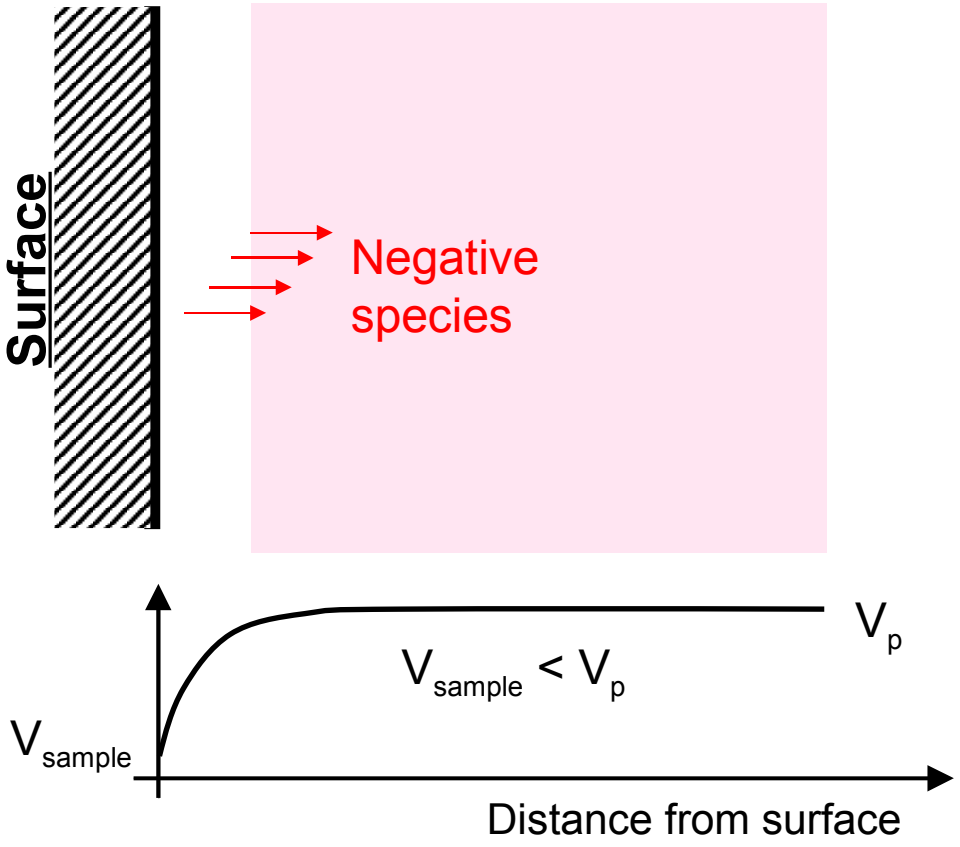


3/ Results of laser photodetachment measurements
(floating regime)

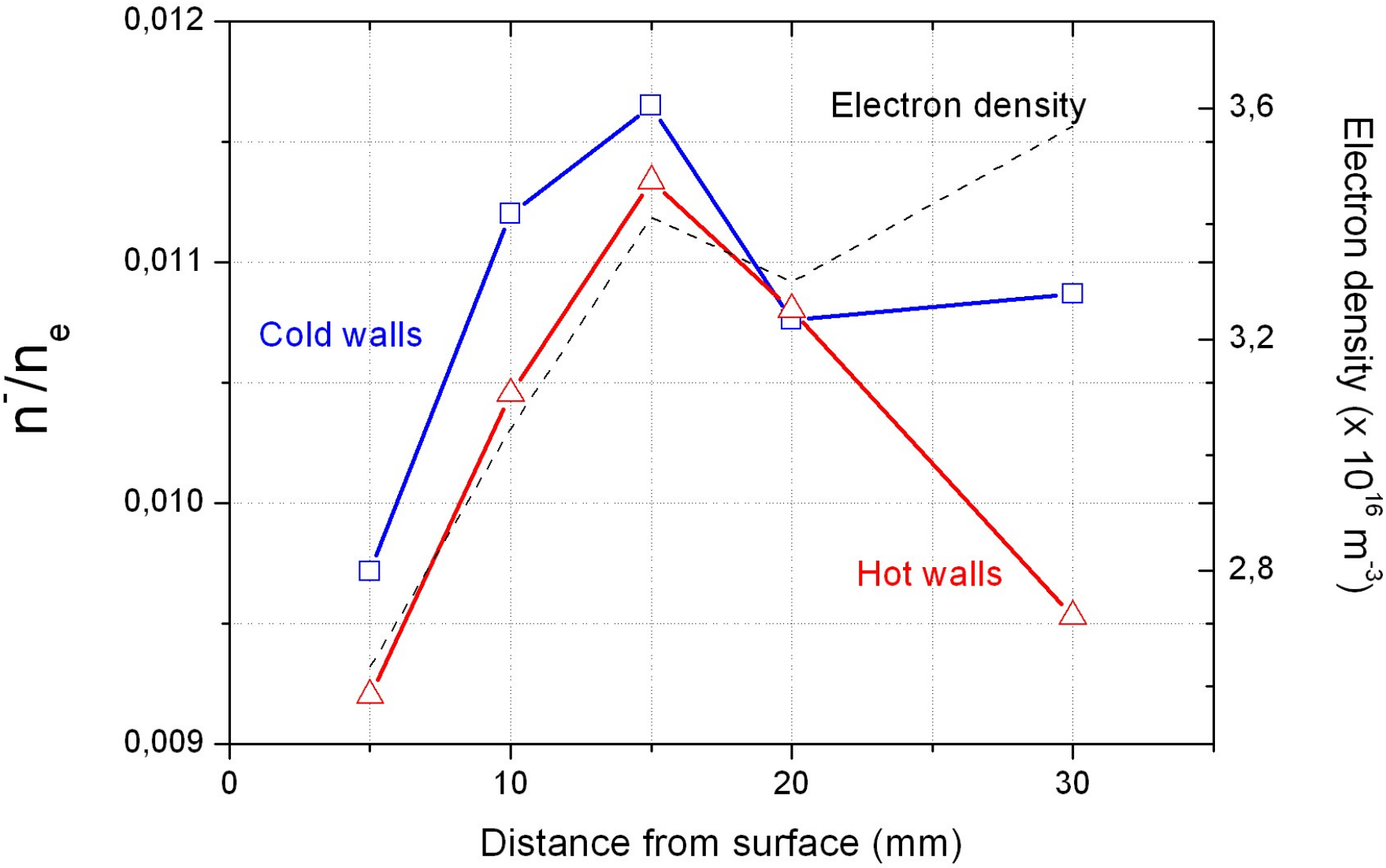
- **Floating samples**
  Raw graphite disc (Ø 70 mm)

  HOPG sample (10 × 10 mm)
- **H_2 plasma**

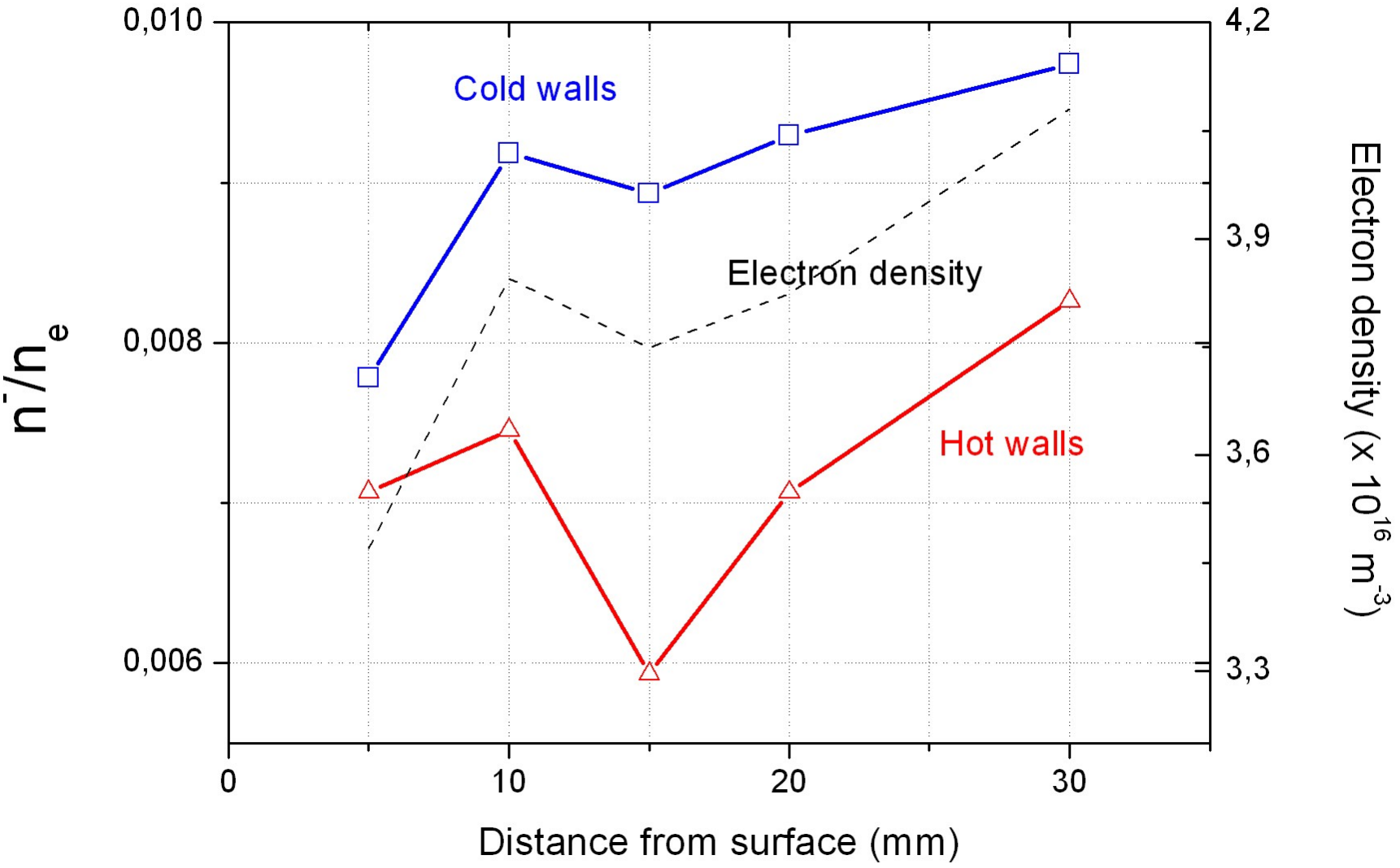
  1 mTorr / 1000 W



Raw graphite floating disc

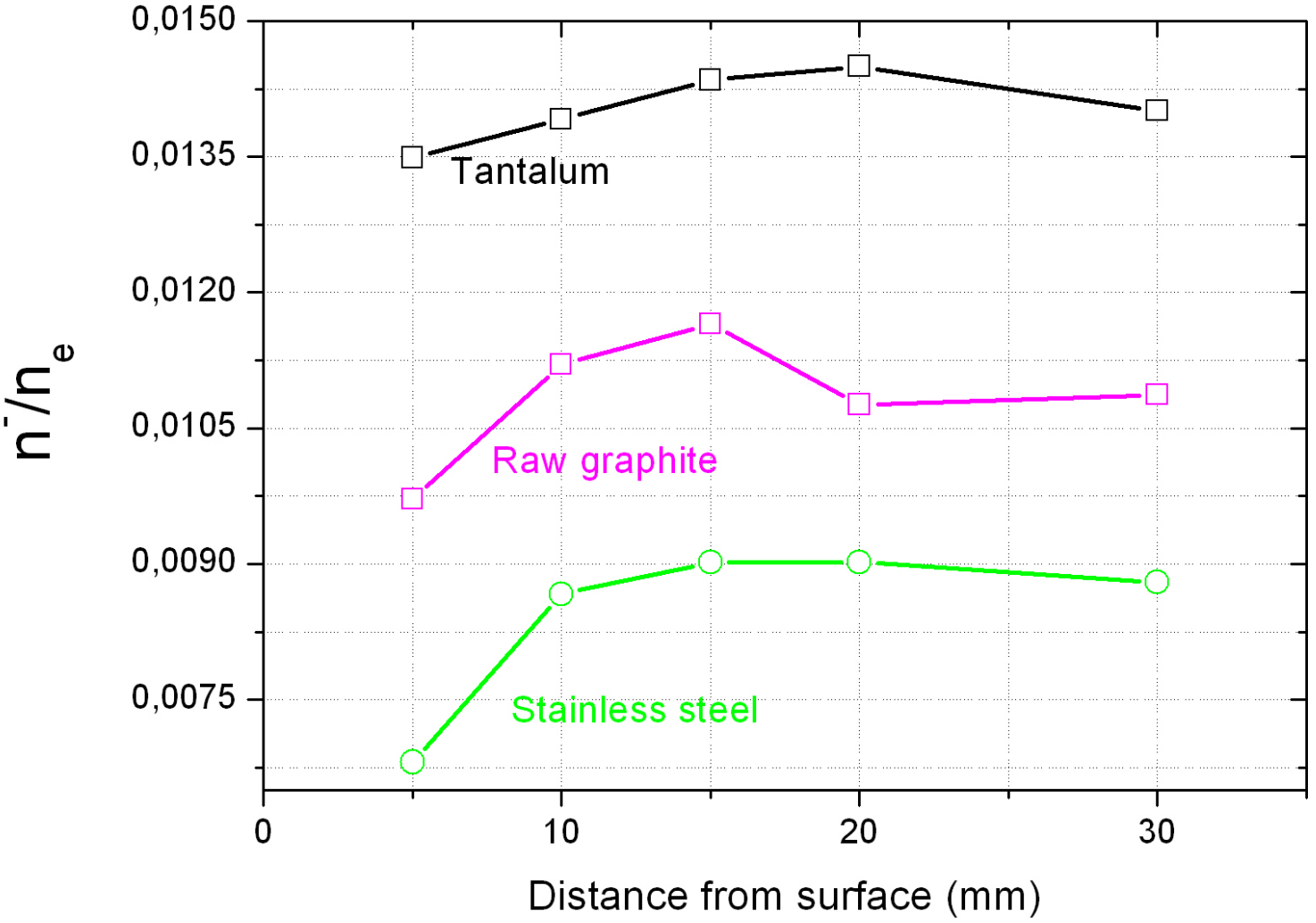


HOPG floating sample

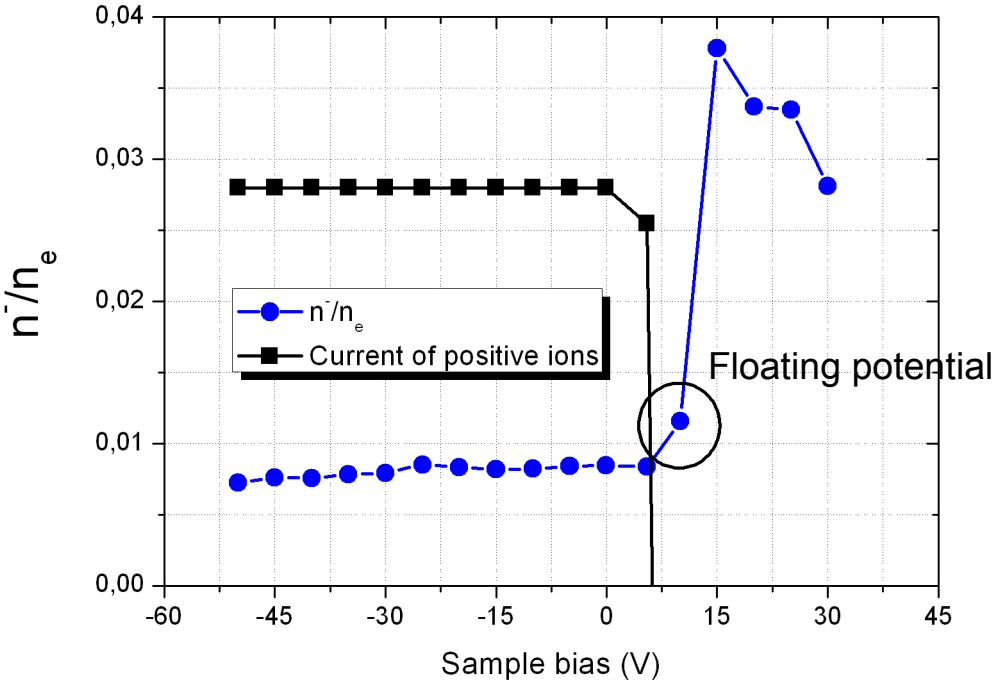


Comparison with Ta and stainless steel (floating regime)

Cold walls regime



3/ Results of laser photodetachment measurements (bias regime)

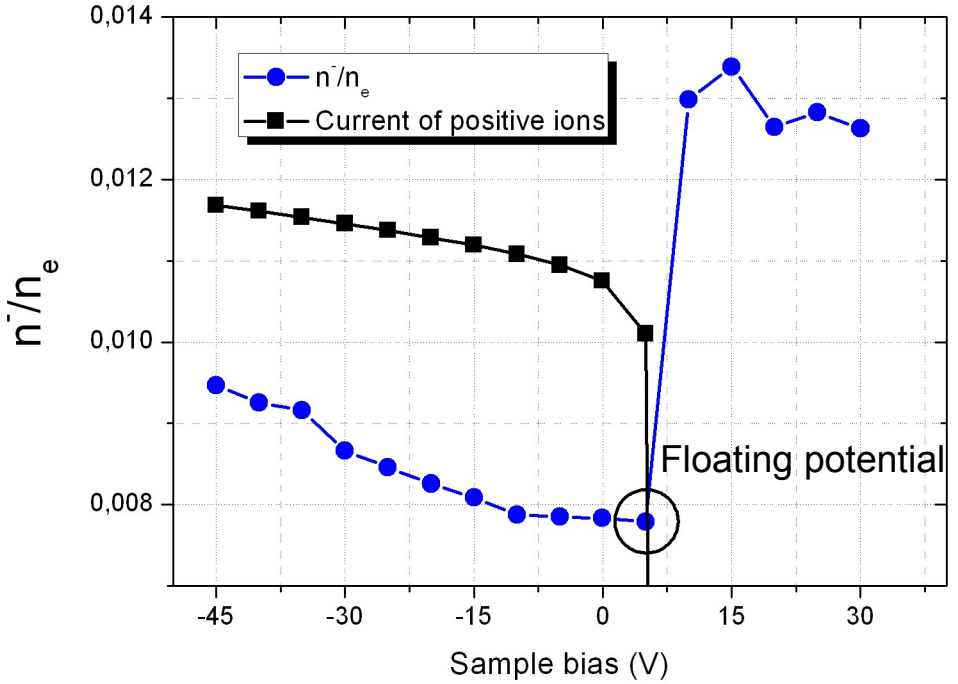


Raw graphite (∅ 70 mm)

- No sheath expansion
- Constant positive ion flux (Bohm)

HOPG graphite (10 × 10 mm)

- Sheath expansion
- Positive ion flux increases

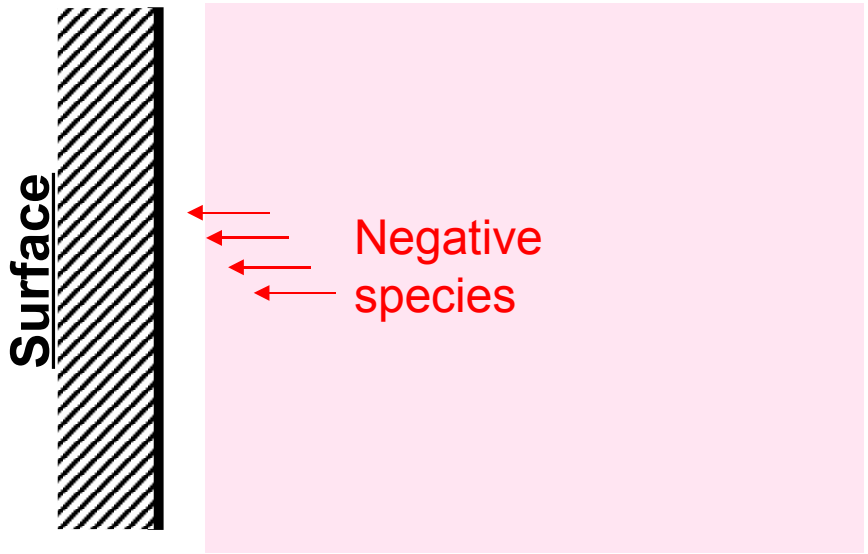


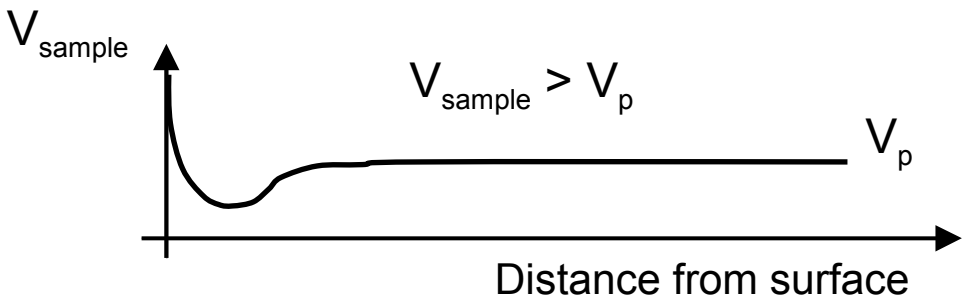
3/ Results of laser photodetachment measurements
(bias regime)

- **Positive bias (+15 V)**
  Raw graphite disc (Ø 70 mm)

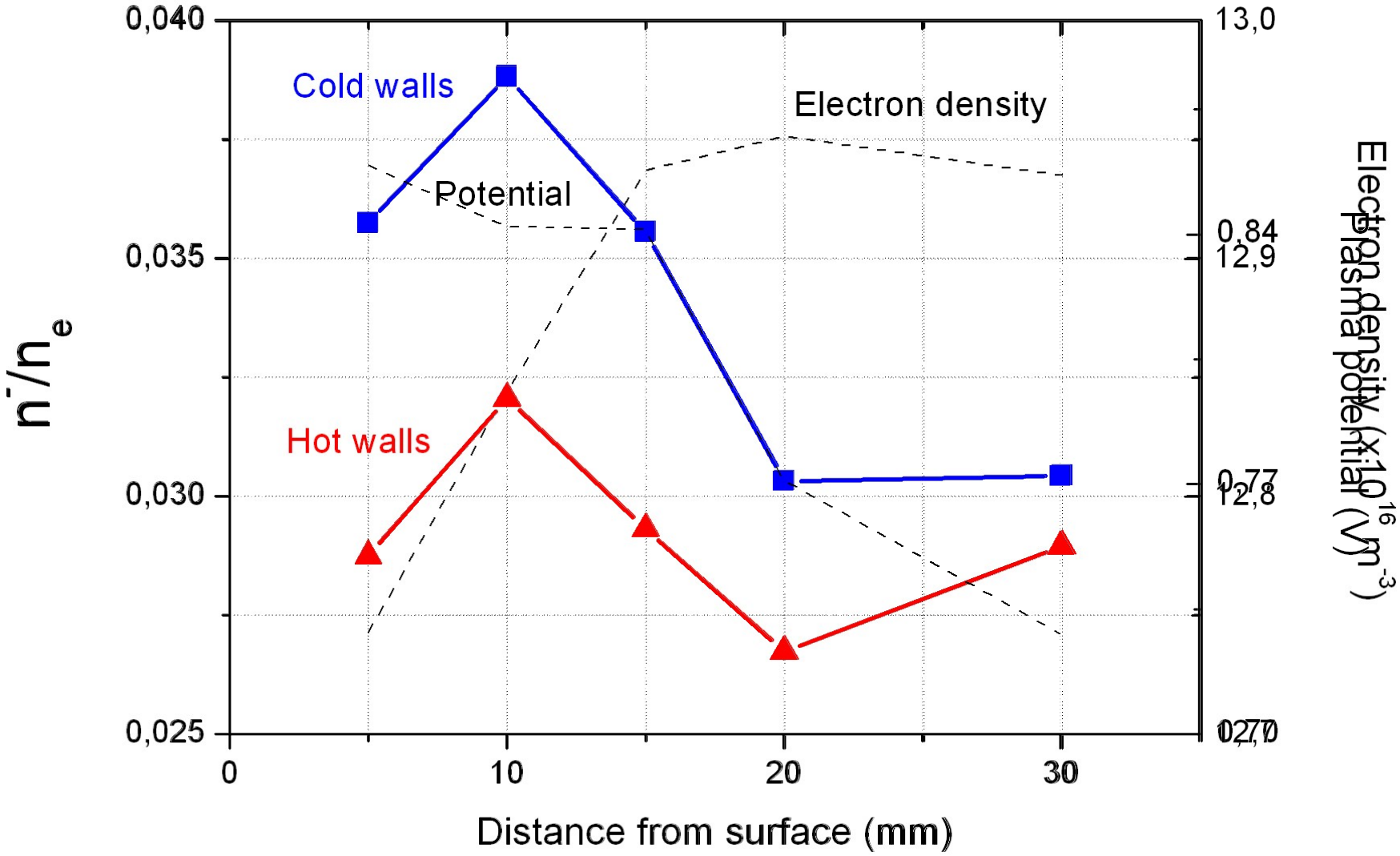
  HOPG sample (10 × 10 mm)
- **H_2 plasma**

  1 mTorr / 1000 W

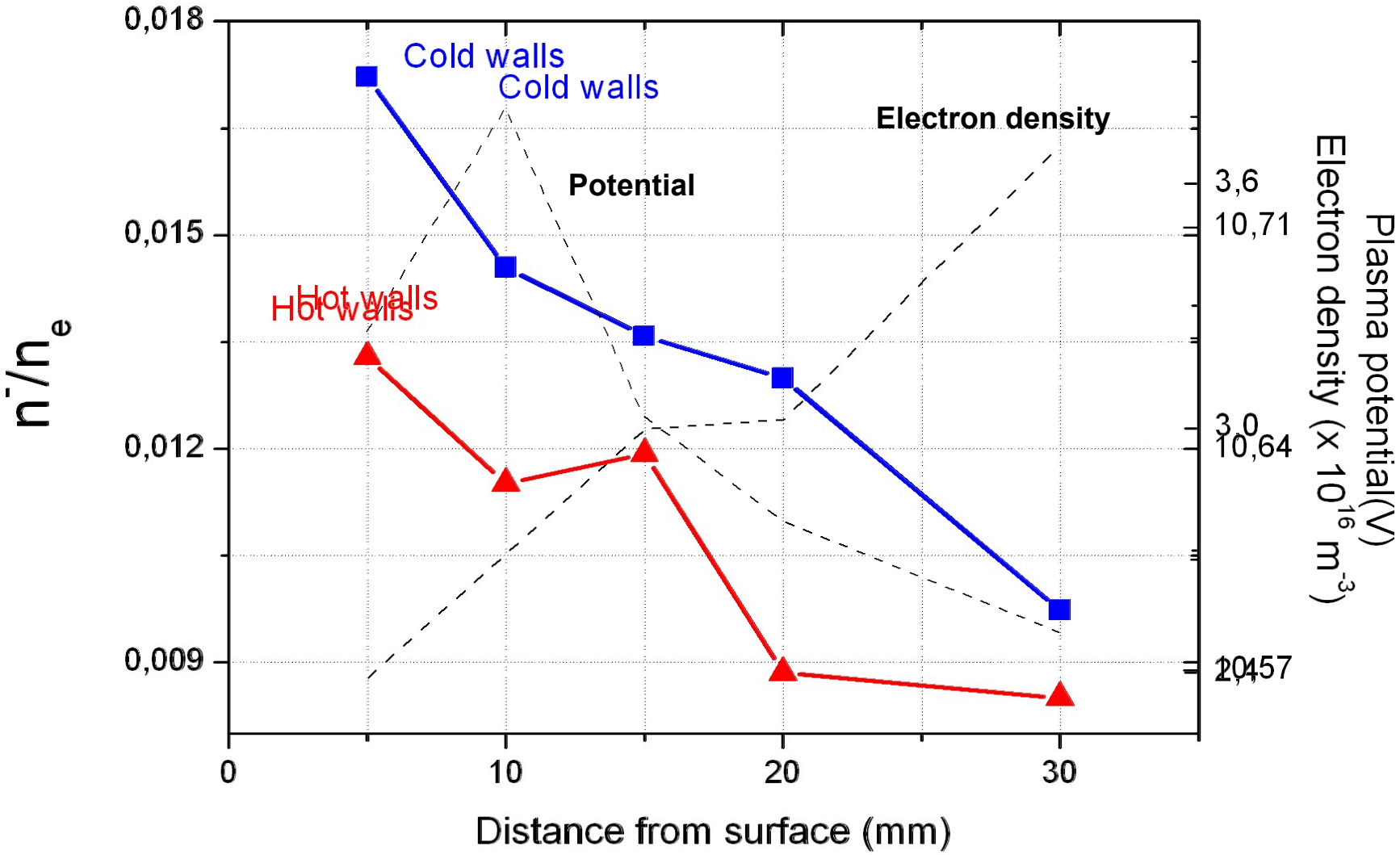




Raw graphite disc biased (+ 15 V)

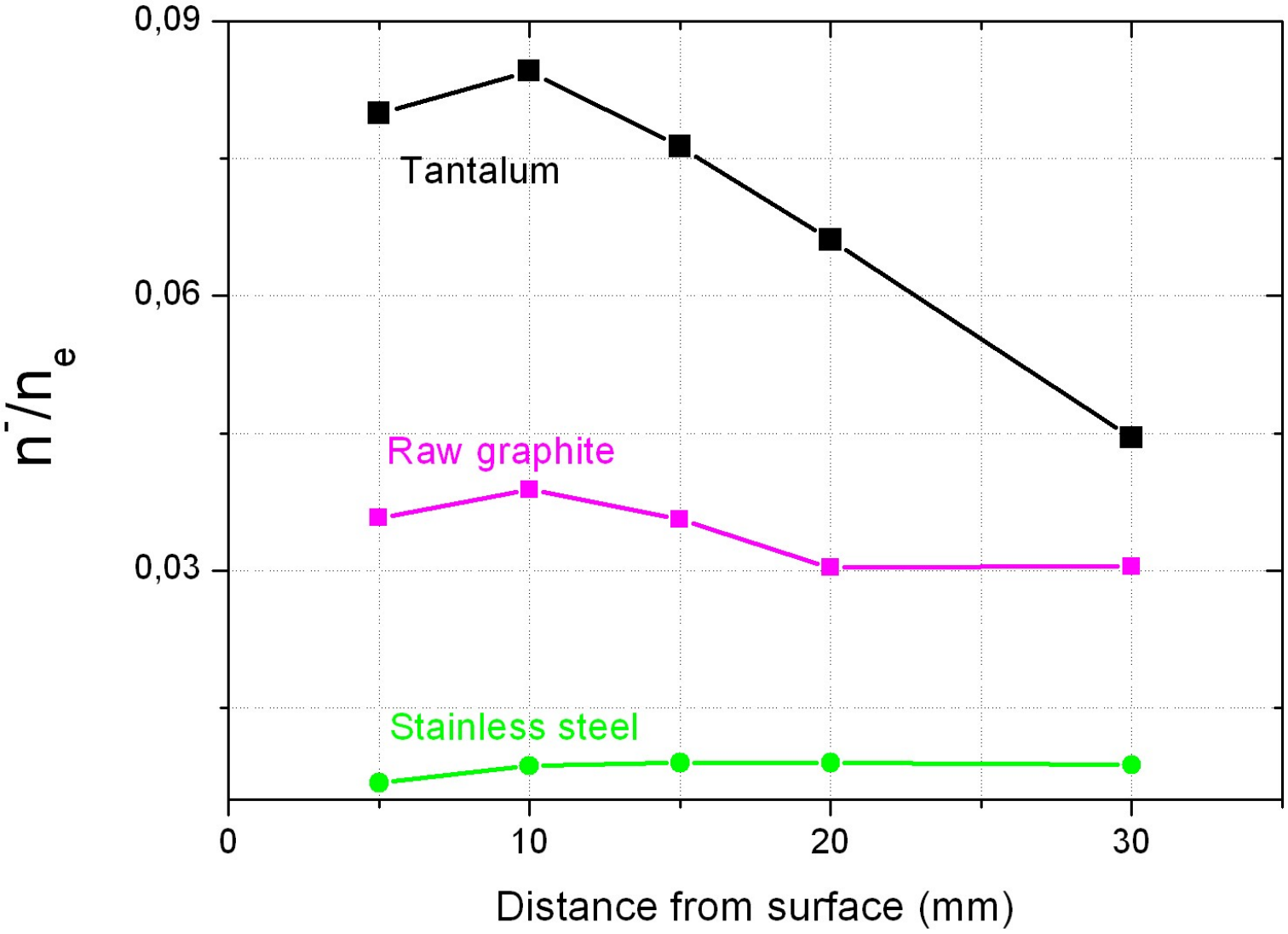


HOPG sample biased (+ 15 V)

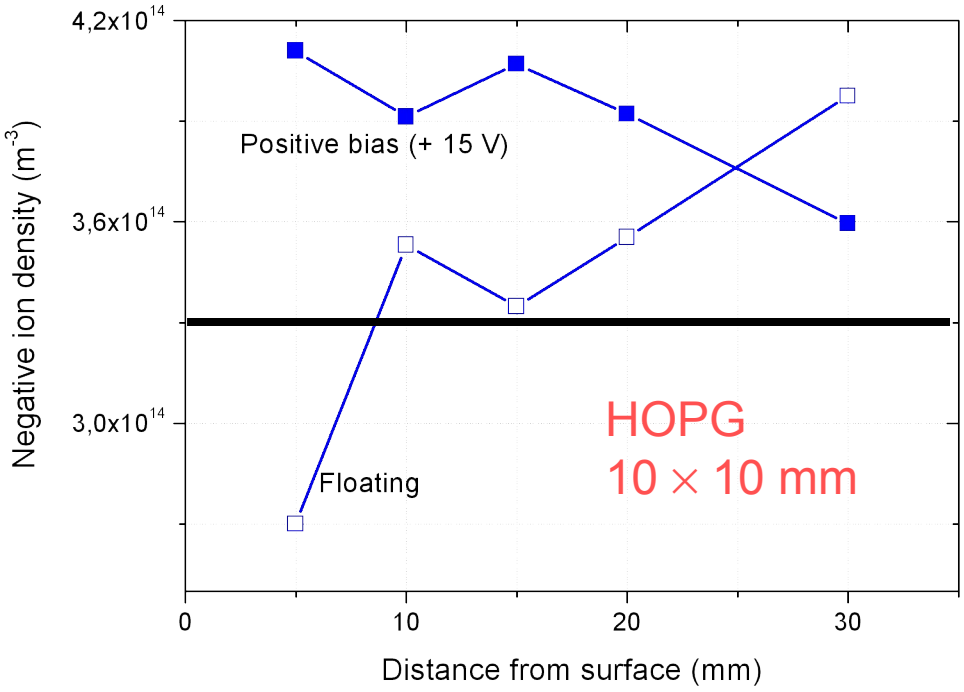


Comparison with Ta and stainless steel
(bias regime)

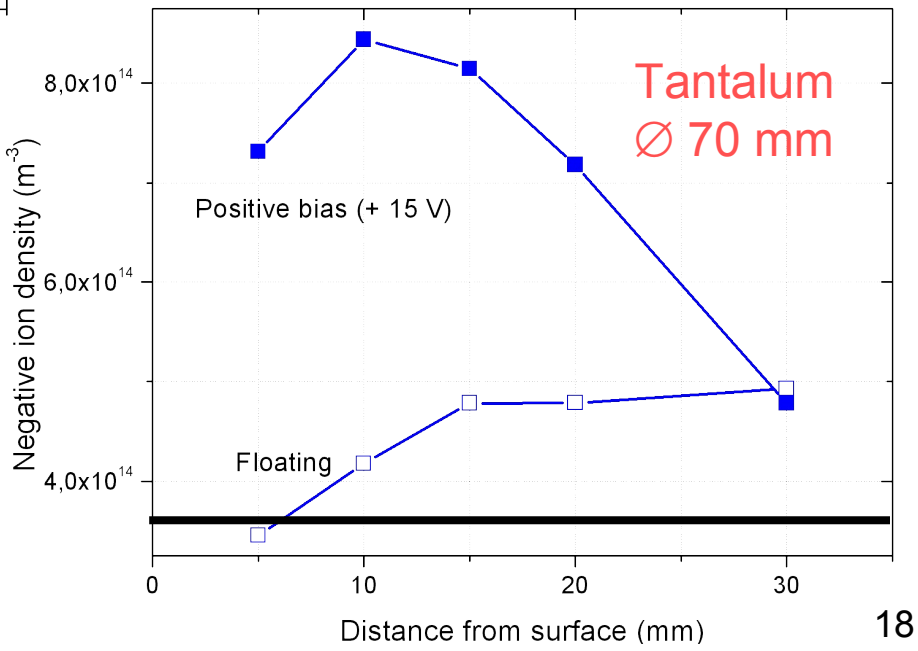
Cold walls regime



Comparison of negative ion density



Volume production (without sample)



4/ Conclusions

- The wall temperature modifies the gas temperature and the degree of dissociation of H_2

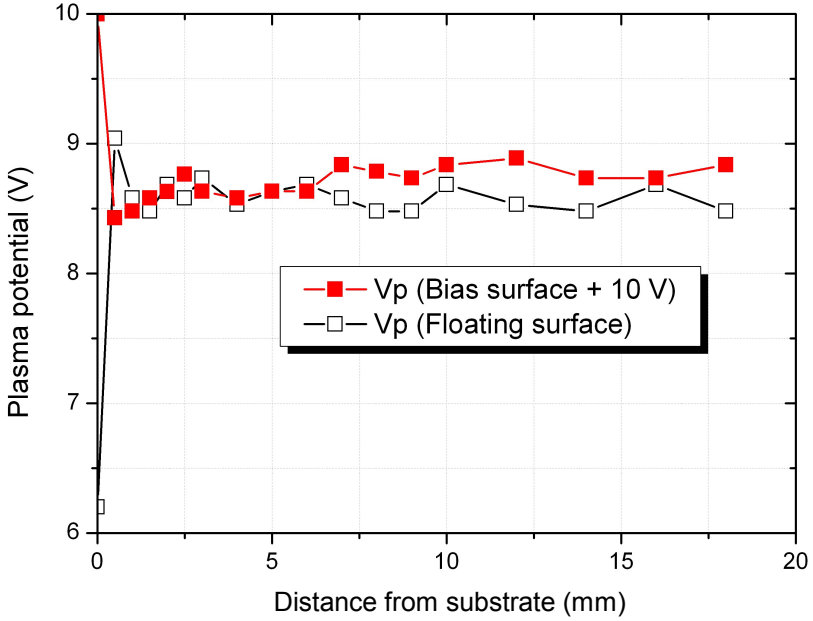
- For all materials the increase of [H] induces an increase of n^-

- <u>In floating regime:</u> analogous n^- and n_e profiles
  ► *surface-vicinity mechanisms* at work

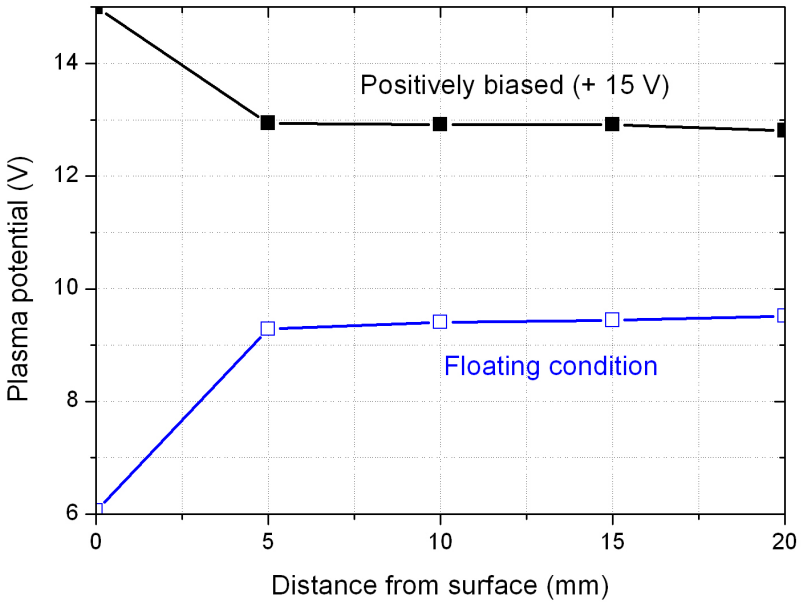
- <u>In positive bias regime:</u> analogous n^- and plasma potential profiles
  ► *surface-vicinity mechanisms* and electrostatic phenomena at work
  (to be confirmed)

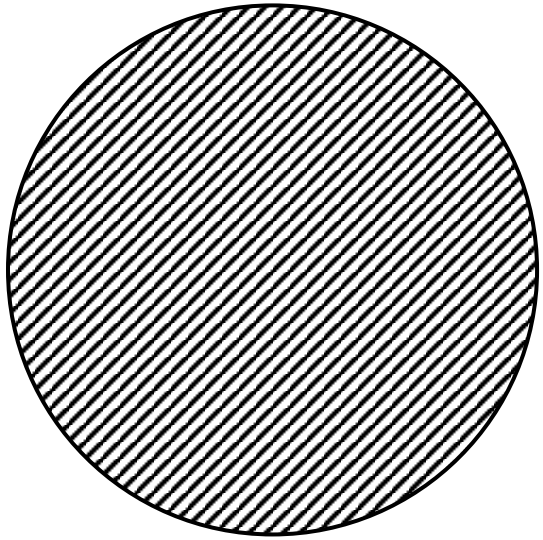
- HOPG graphite very promising to efficiently produce vibrationally-excited H_2
  ► n^- increases by 20 % for a very small surface
  (and by 155 % for a surface of tantalum roughly 38 times larger)

3/ Results of Langmuir probe measurements (biased regime)



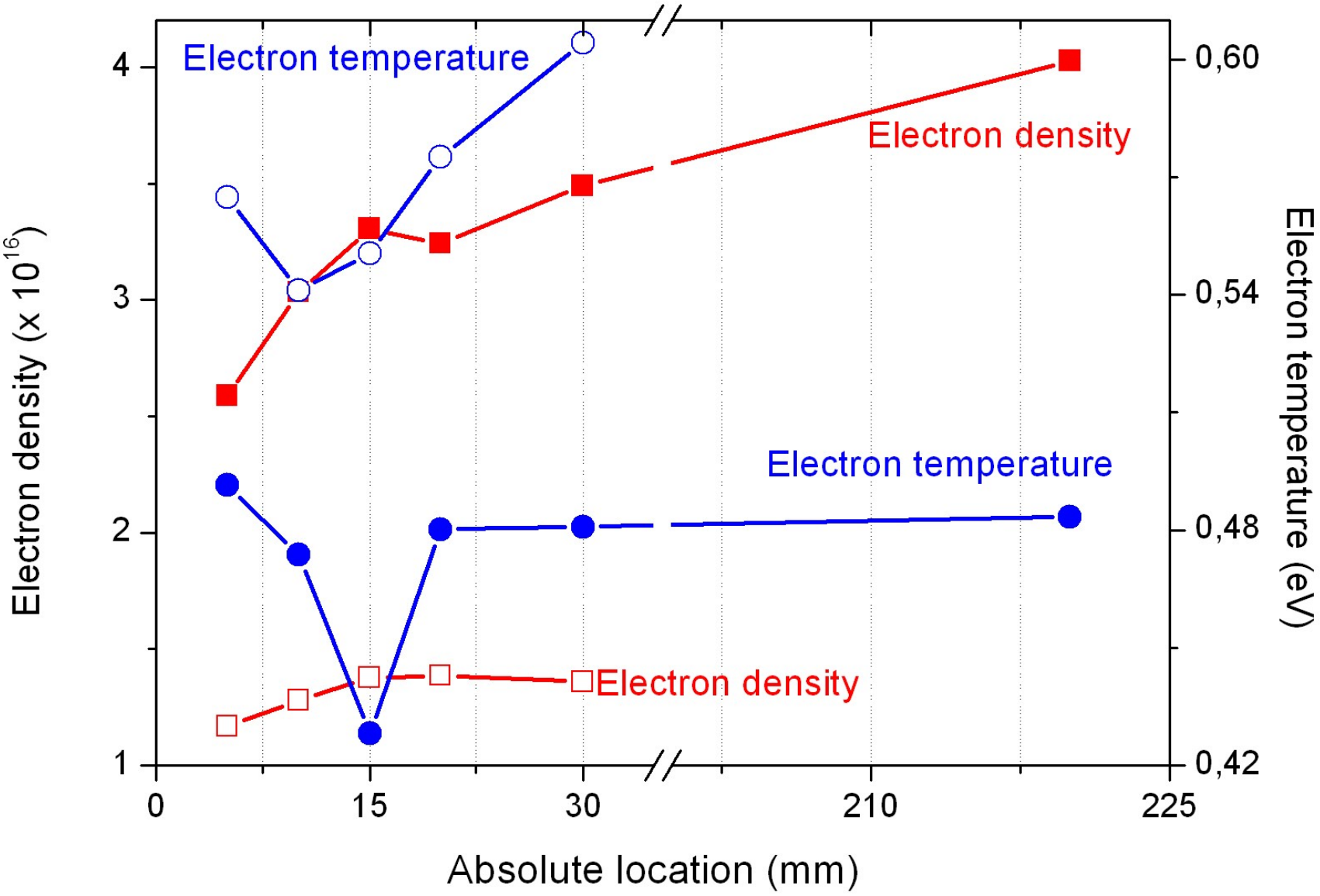
• square sample 10 × 10 mm





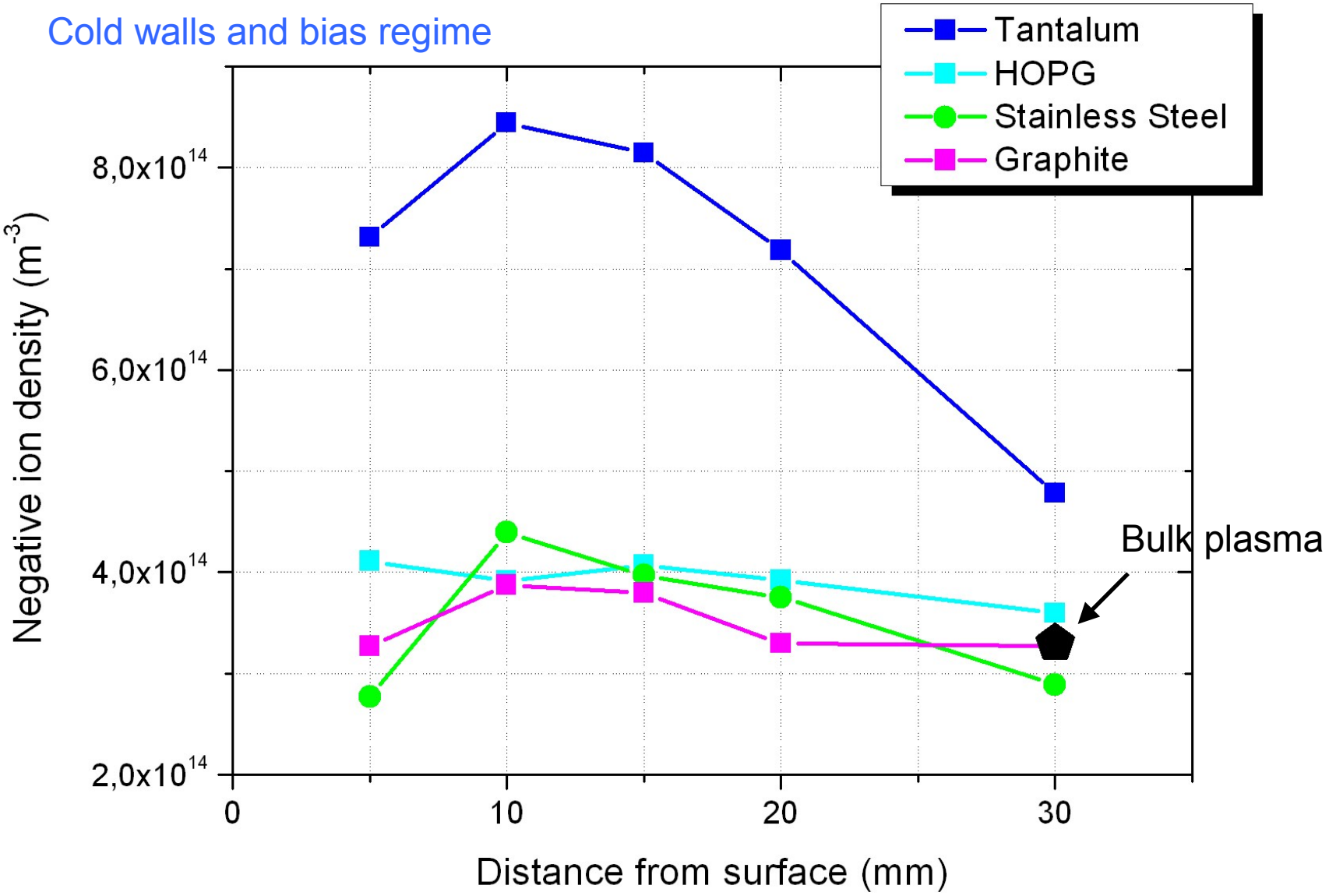
• Disc Ø 70 mm

Results of Langmuir probe measurements
(Floating & biased regime)

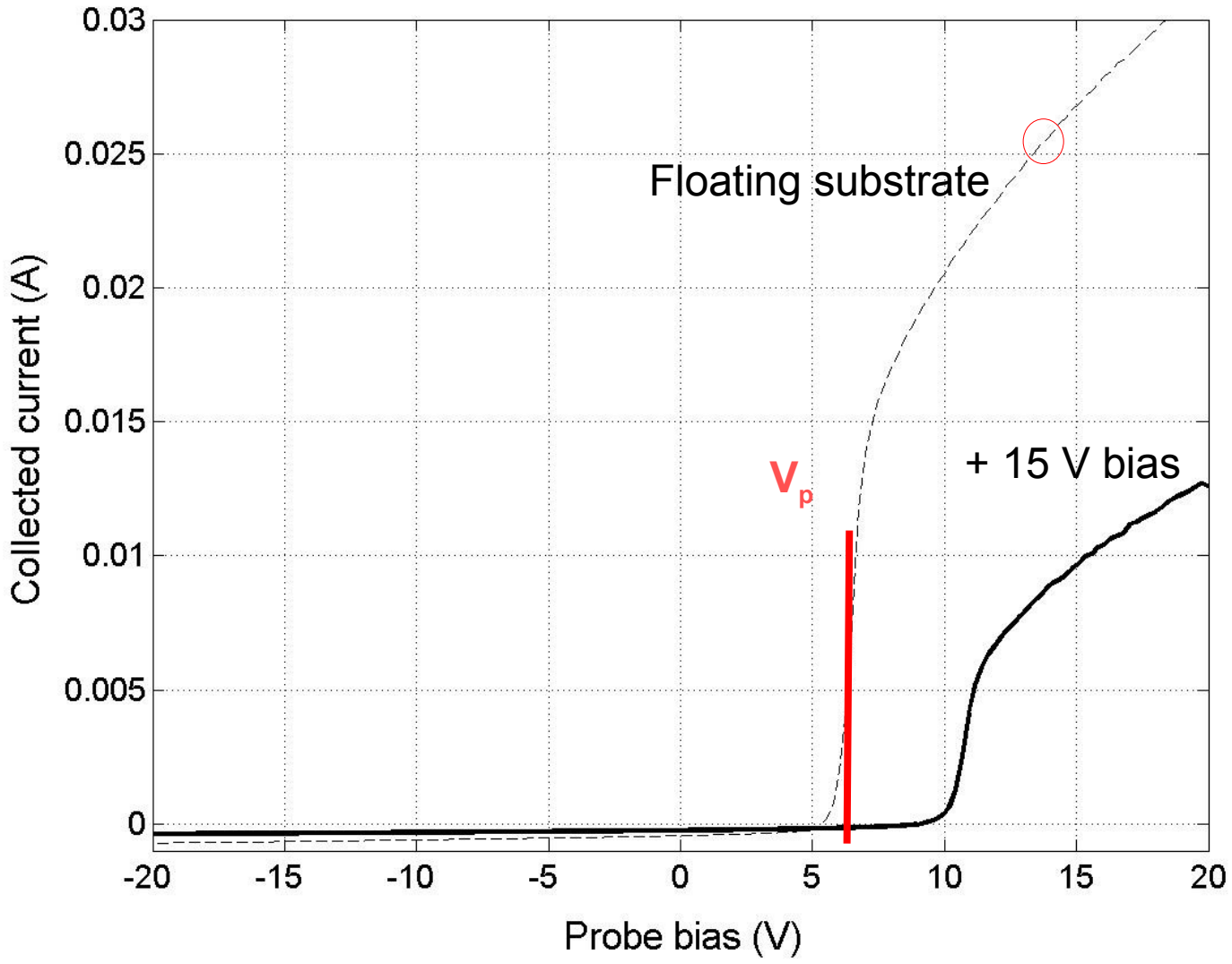


Comparison of negative ion density

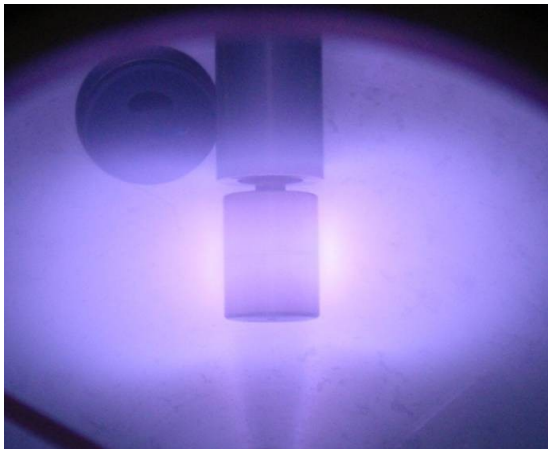
Cold walls and bias regime

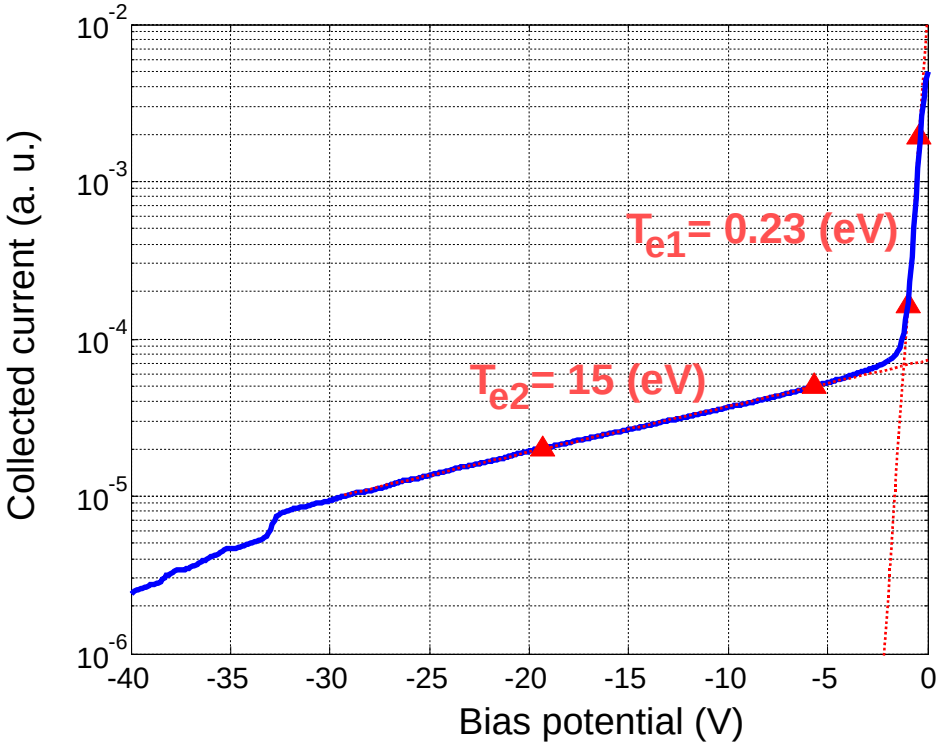


Results of Langmuir probe measurements
(biased regime)



Experimental set-up





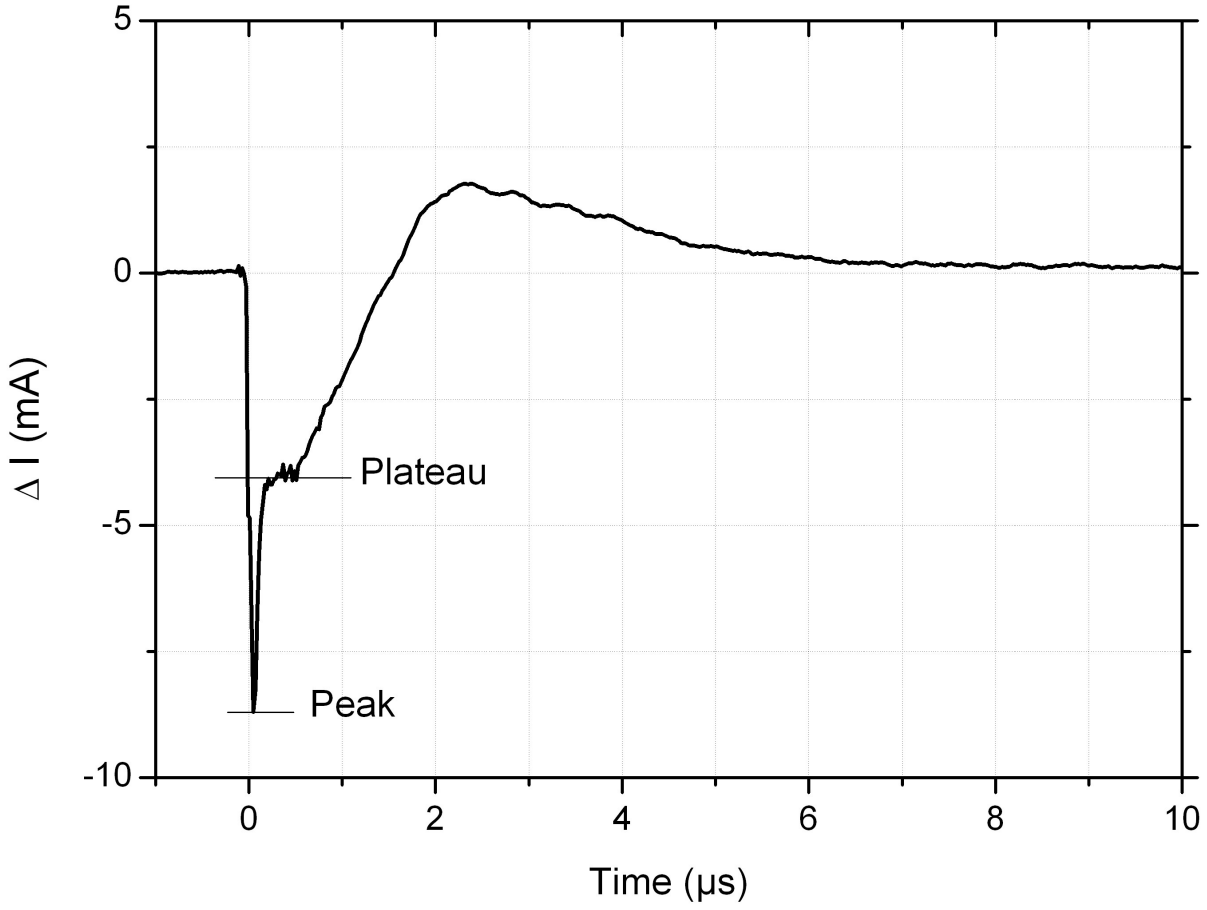
H^-/D^-

Dissociative attachment (DA)

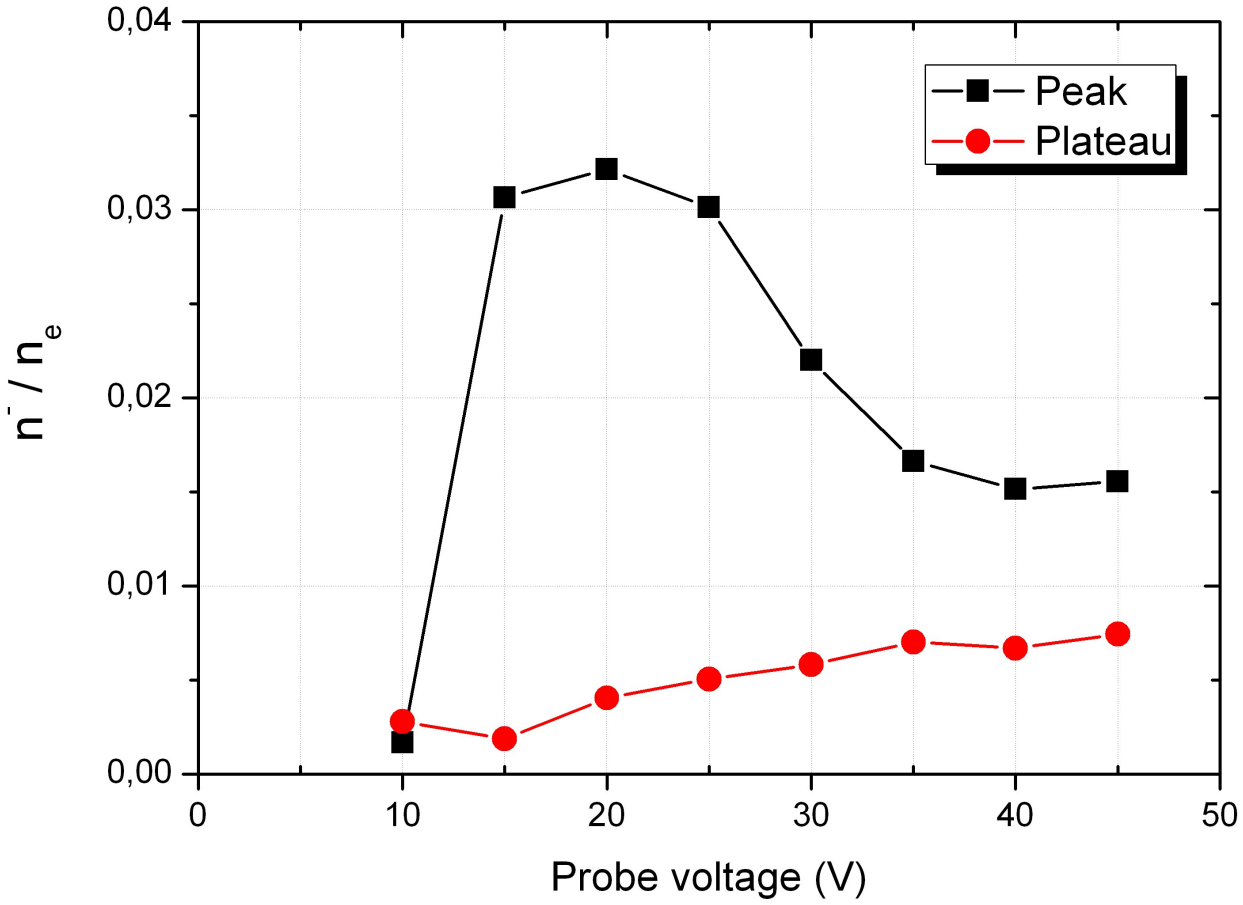
H_2 / D_2 → H_2 (r, v") / D_2 (r, v")

Vibrational excitation

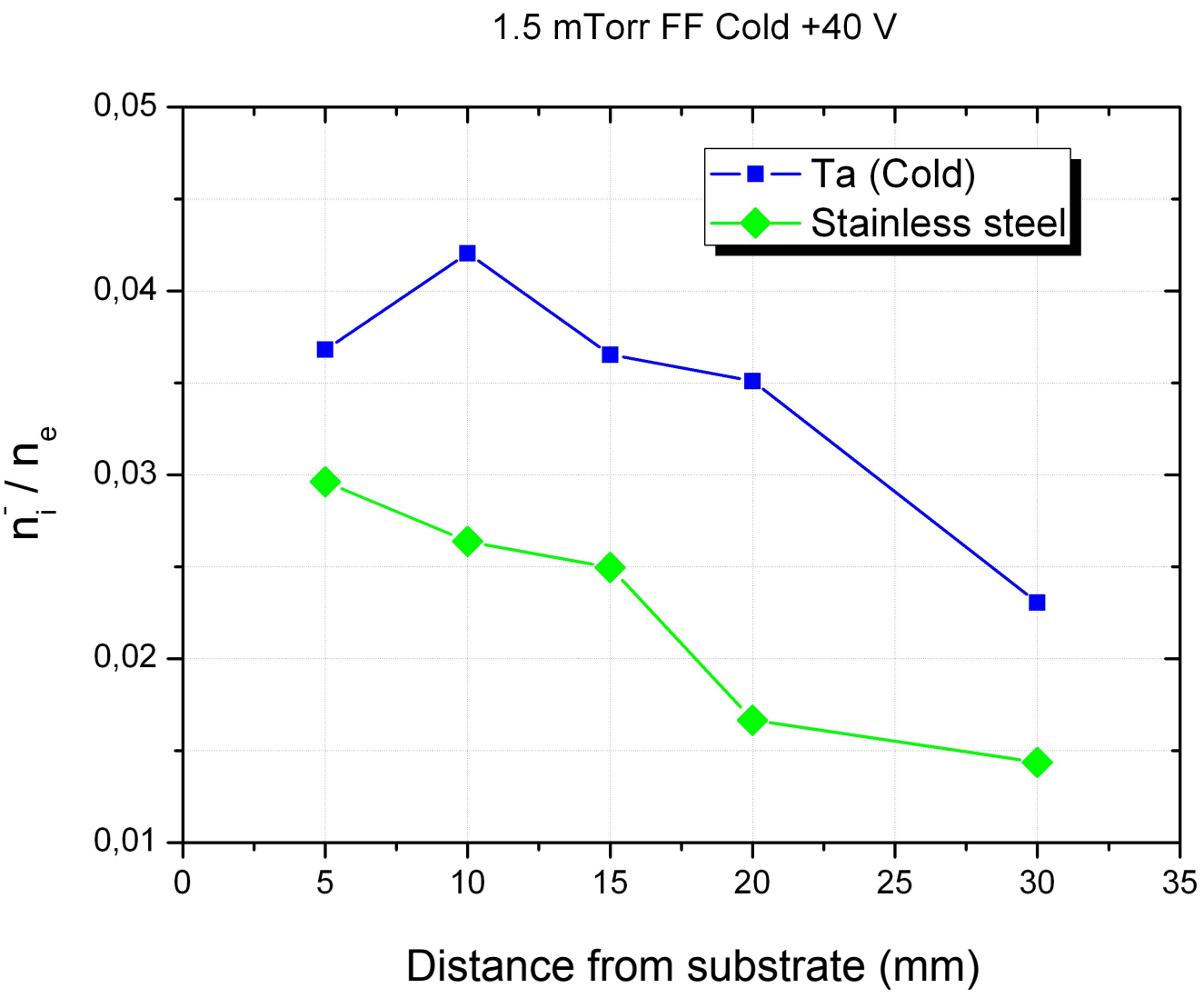
Laser photodetachment



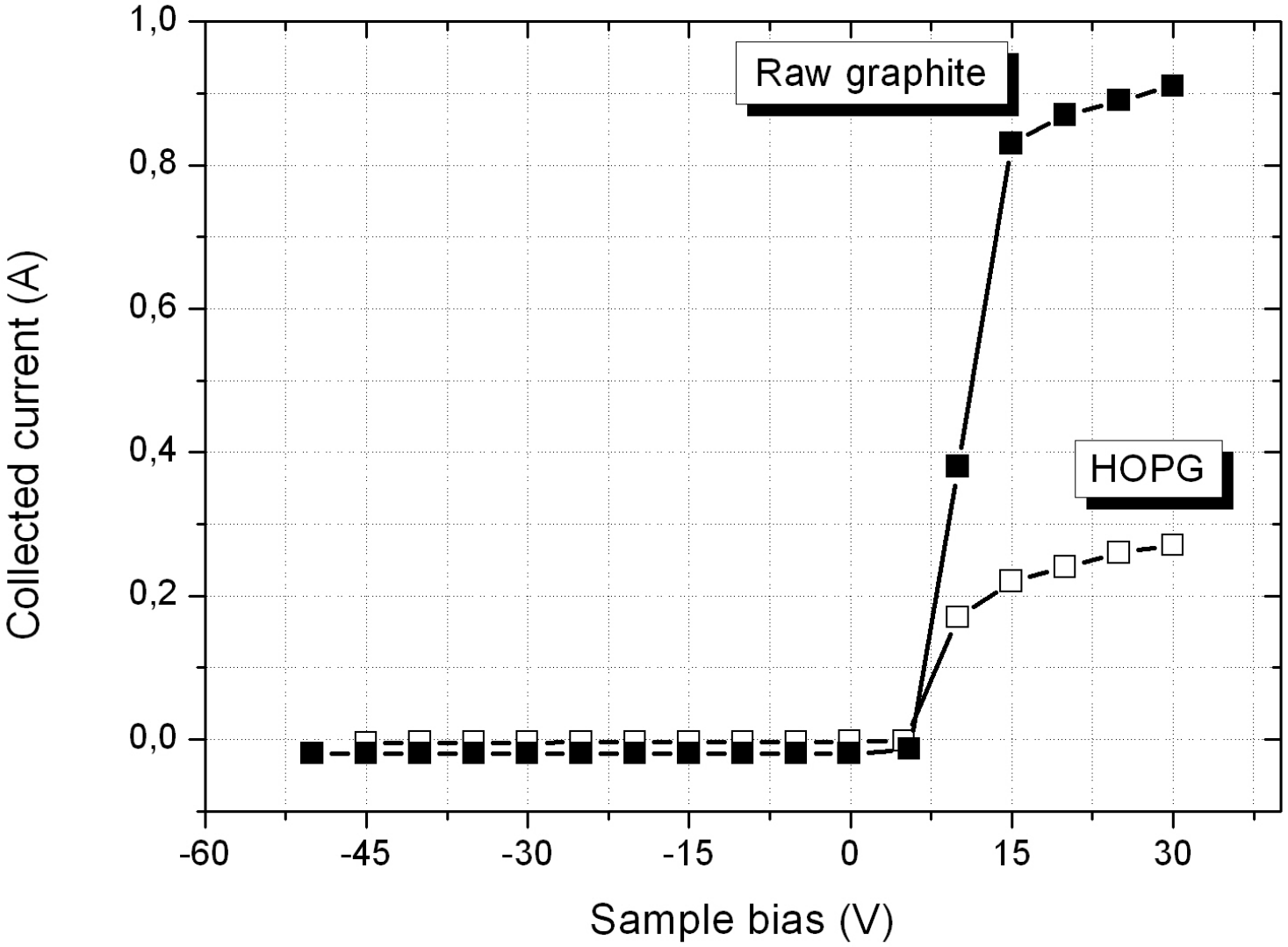
4./ Results (Photodetachment)



4./ Results (Photodetachment)



Sample Bias


Raw graphite
HOPG
Collected current (A)
1,0
0,8
0,6
0,4
0,2
0,0
-60
-45
-30
-15
0
15
30
Sample bias (V)