AG Experimentelle Plasmaphysik (EPP)
University of Augsburg

Efficiency of Cs-free Materials for H^-/D^- Production

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ThuO6

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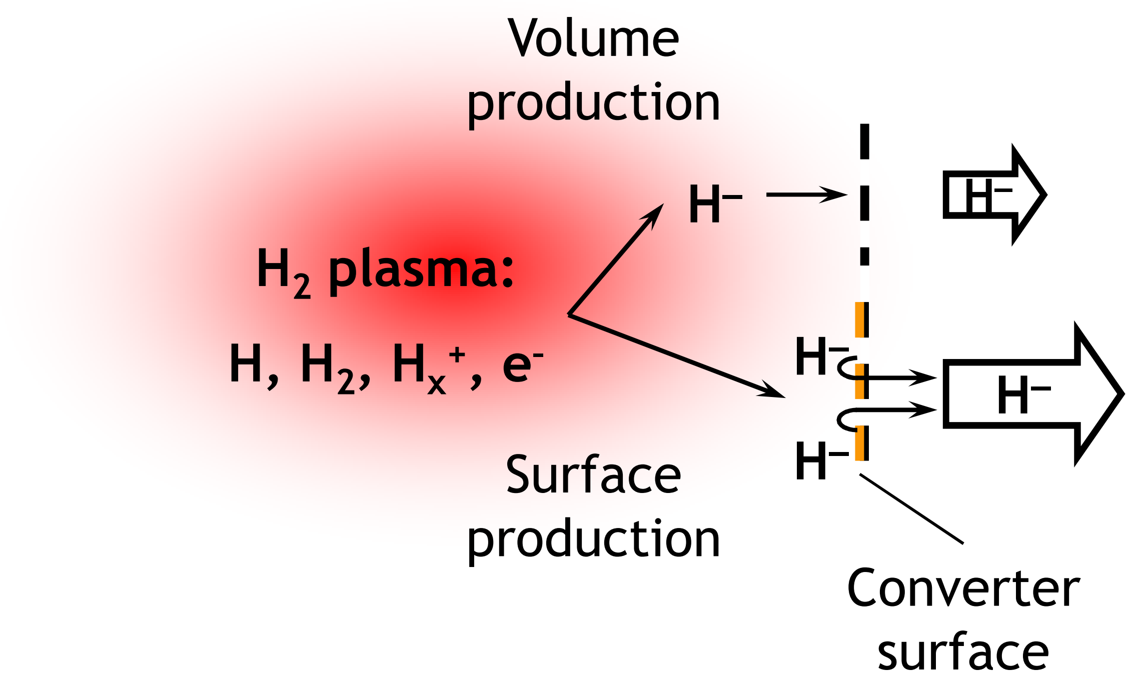
Negative Hydrogen Ion Sources



High performance

- high current dens.
- reliable & reproducible
- stable (long pulses)
- homogeneous (large beams)

Caesiation → low WF

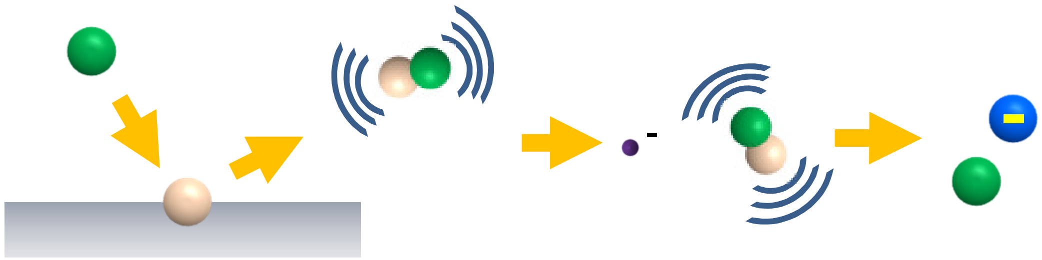
- Cs chemical reactive
- Complex redistribution dynamics

Issues

- Careful conditioning
- Cs consumption
- Diagnostics

→ Alternatives to Cs?

Surface Assisted H^- Formation

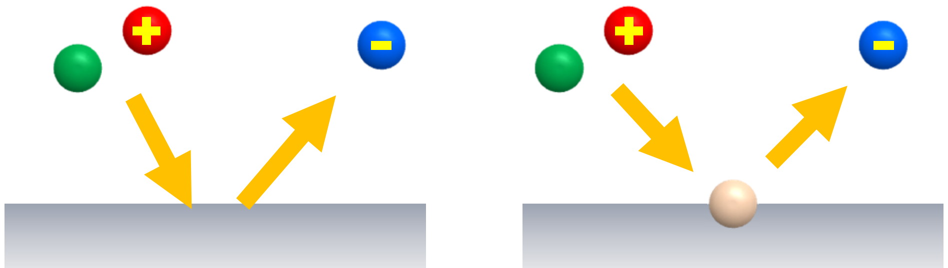


Surface reformation

$H + H_{ads} \rightarrow H_2(\nu)$

Volume production (DA)

$H_2(\nu) + e^- \rightarrow H + H^-$



Direct e^- capture

Sputtering of ads. H

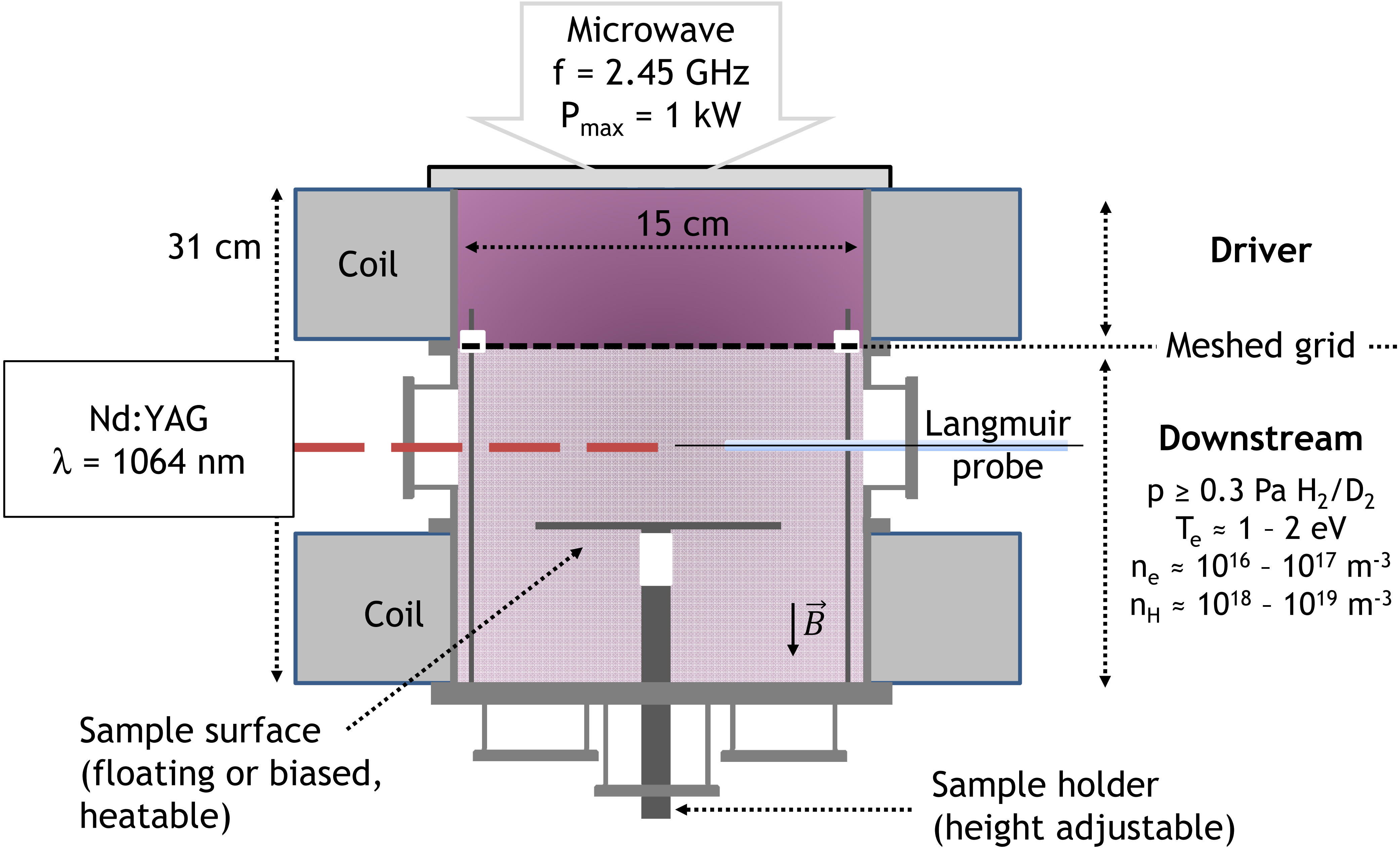
$H, H_x^+, H_{ads} + e^- \text{(surface)} \rightarrow H^-$

Low work function beneficial

Effect	Materials
Supporting volume formation	Refractory metals (W, Ta)
Direct conversion	Caesiated surfaces
	Inherent low WF (LaB_6, MoLa)
	Carbon materials (Diamond, BDD)

Comparative studies under identical and controlled conditions close to ion source parameters

Laboratory Experiment HOMER (ECR)



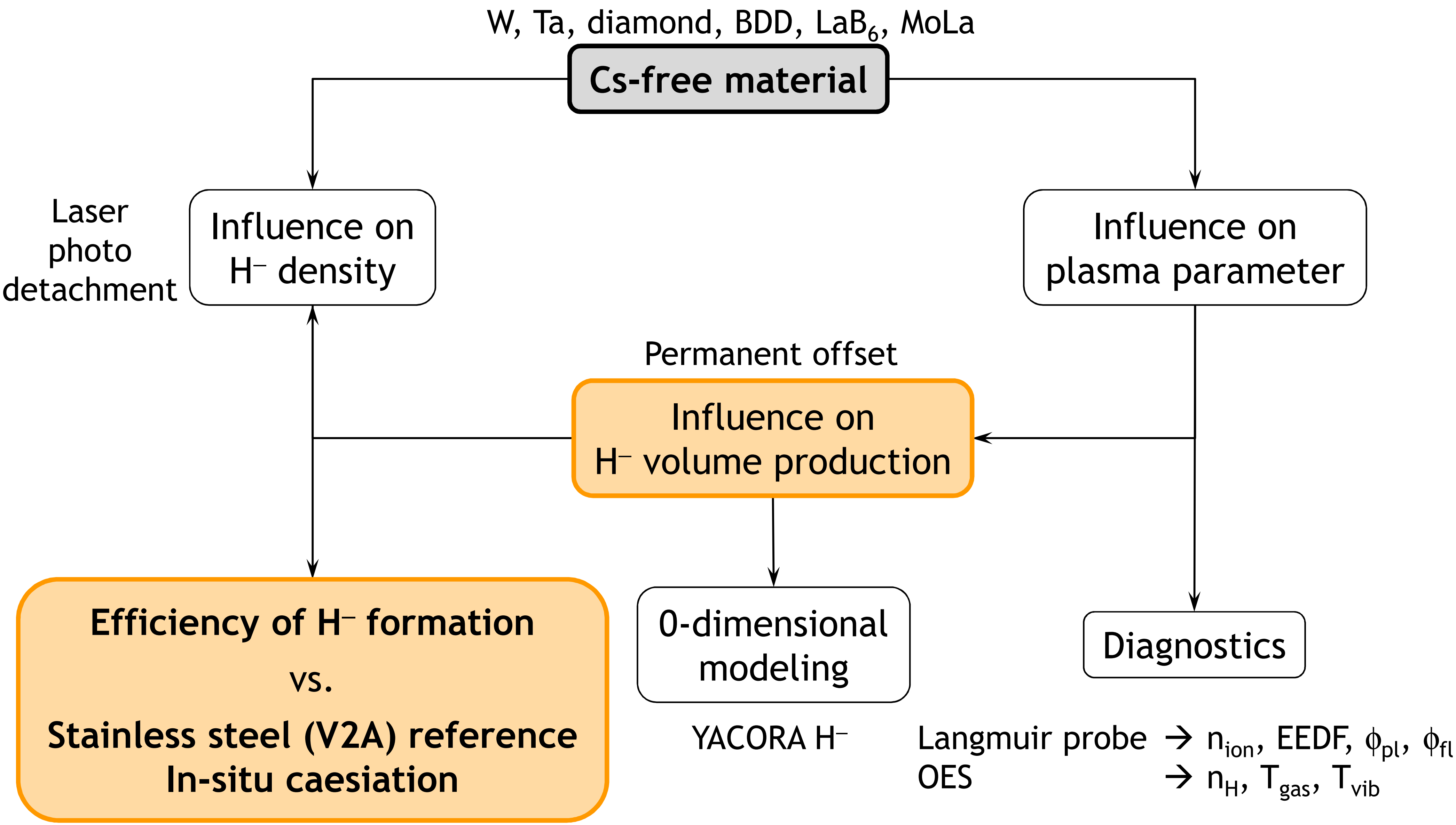
Investigated Materials

Effect	Material group	Materials	Work function
Supporting volume formation	Refractory metals	Bulk Tantalum (Ta), Bulk Tungsten (W)	–
Direct conversion	Caesiated surfaces	Stainless steel + Cs (in-situ)	2.1 eV (bulk)
	Inherent low WF	Lanthanum-doped molybdenum (0.7 % La, MoLa), Lanthanum hexaboride (LaB_6)	< 3 eV < 3 eV
	Carbon materials	Non-doped diamond, Boron-doped diamond (BDD)	–

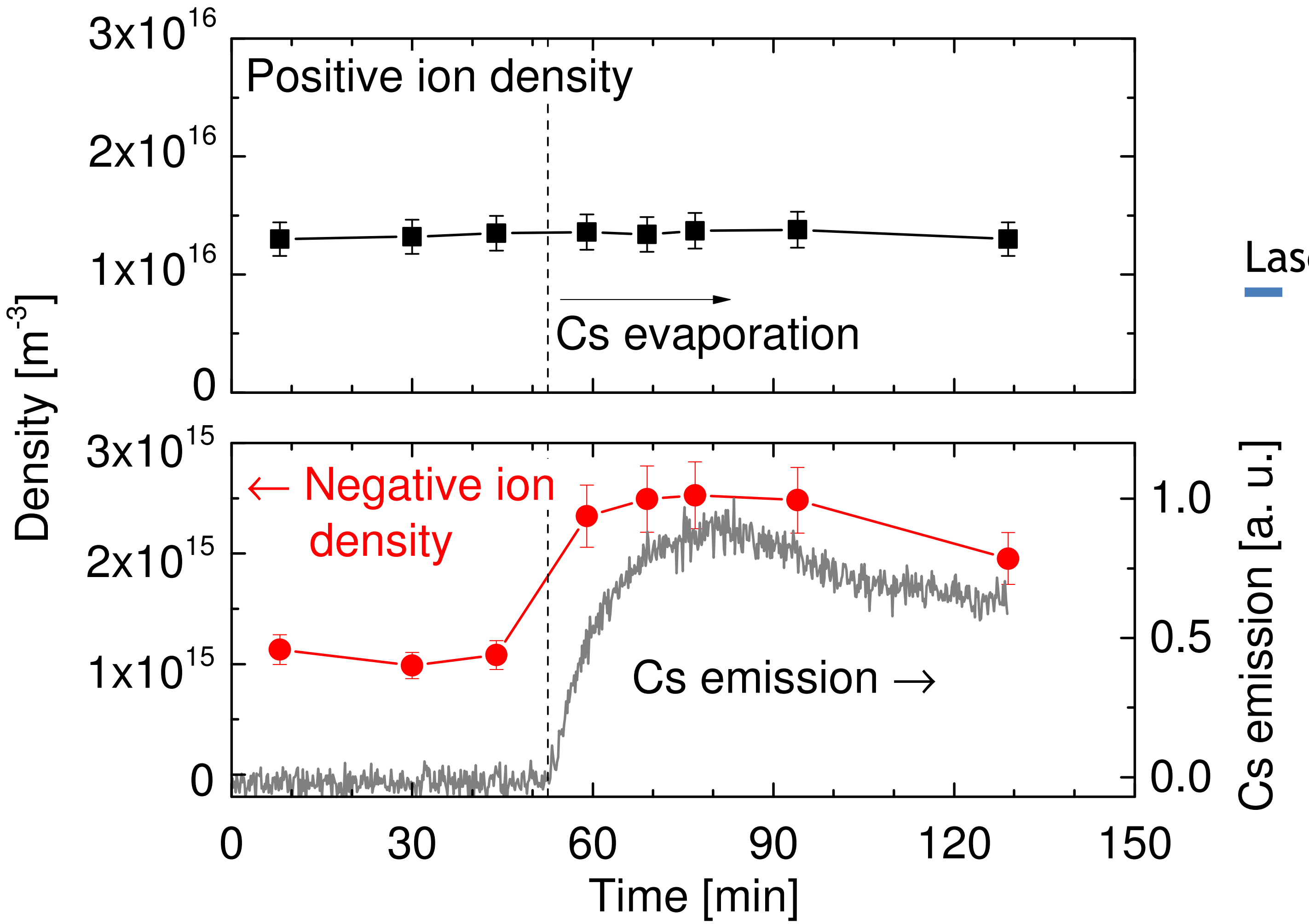
Investigations of H^- density depending on:

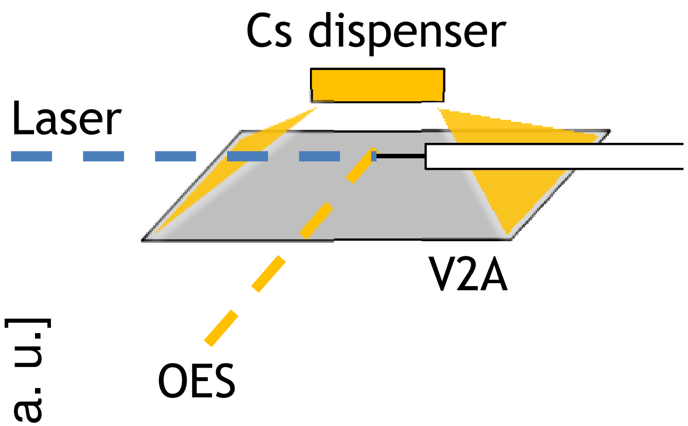
- Pressure: 0.3 – 3.0 Pa
- Distance: 1.5 – 4.5 cm
- Sample bias: -30 – +30 V
- Temperature: 100 – 550 °C

Rating of Cs-free Materials



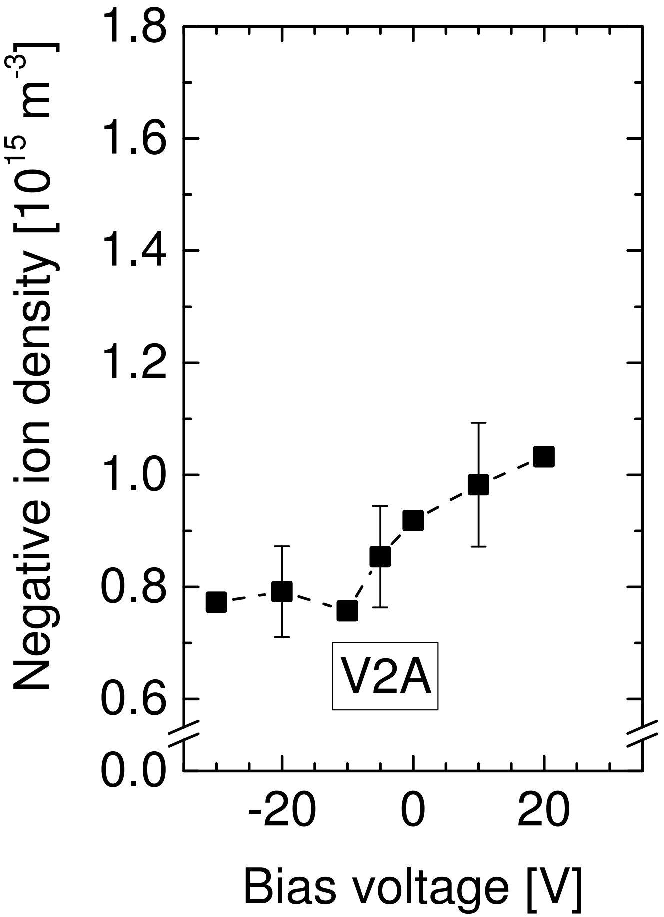
Target for Cs-free materials - Cs





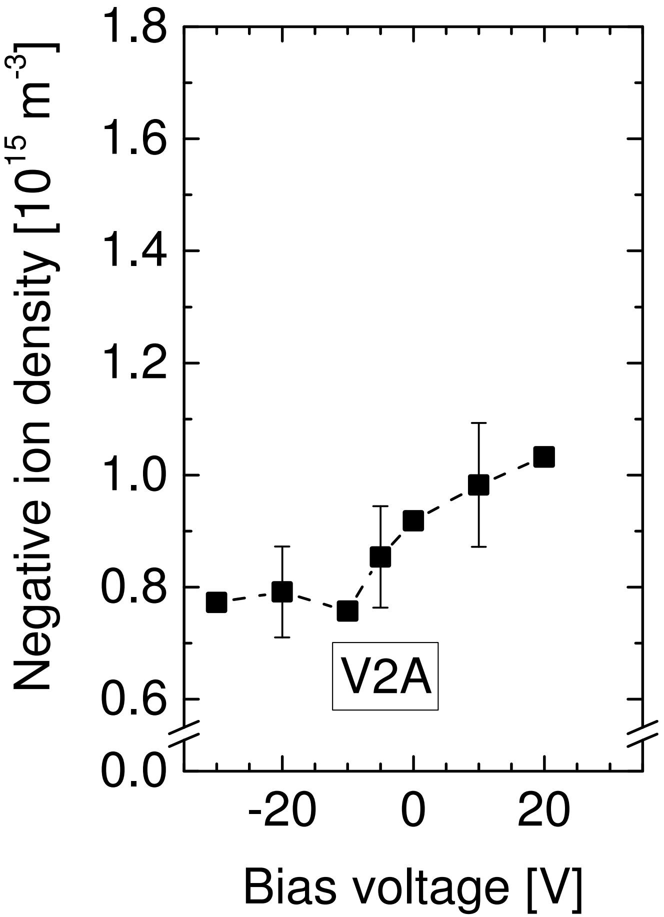
- ➢ $\chi_{Cs} \approx 2.1$ eV (confirmed at lab exp. ACCesS → Poster MonP18)
- ➢ H^- density increased by a factor of 2.5 → **Goal for Cs-free materials**

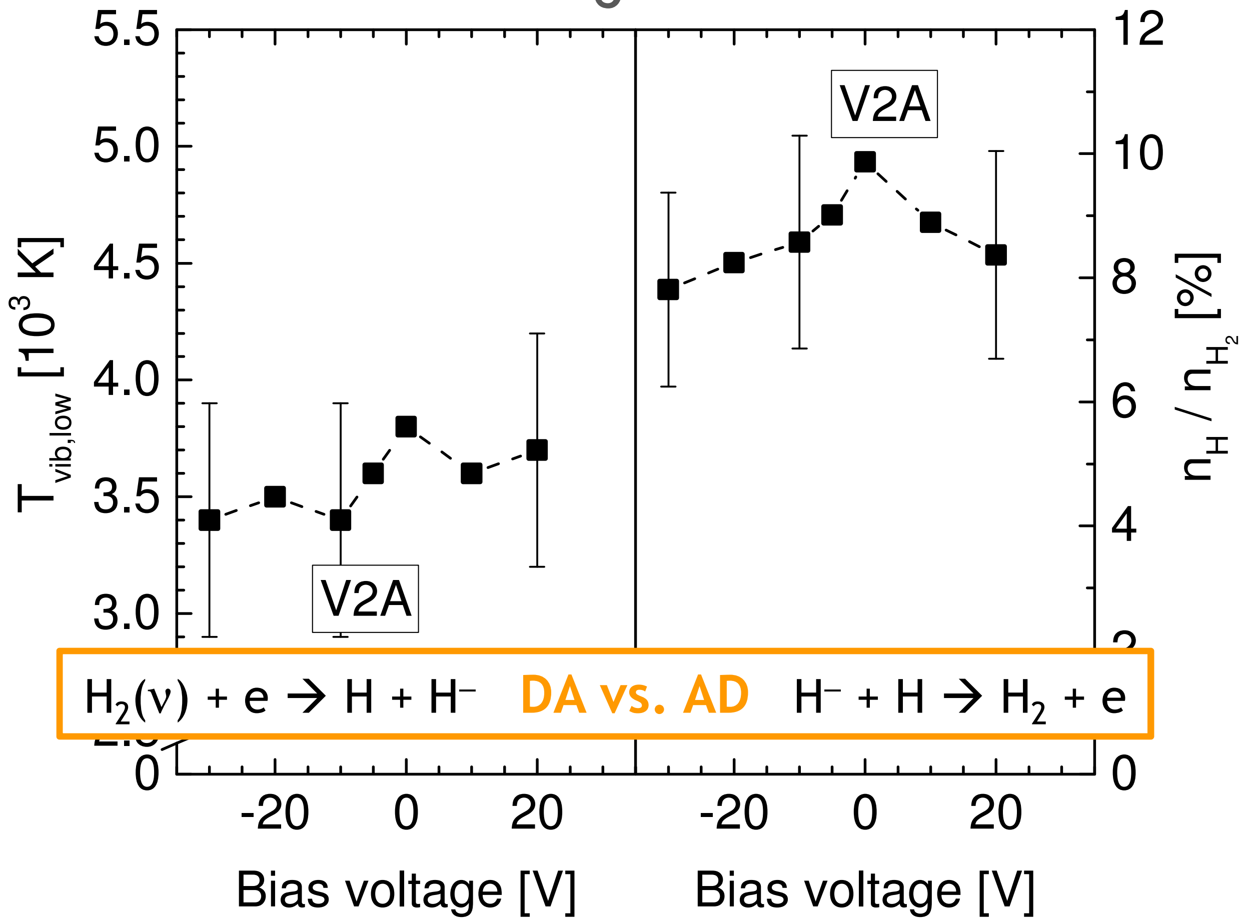
Cs-free Materials – LaB_6 & BDD



- Bias between sample and vessel walls
  - Influence on energy of charged particles impinging/leaving the surface
  - Influence on plasma parameters
- Plasma potential always higher
  - Particle energy varies between 20 eV and 1 eV

Cs-free Materials – LaB_6 & BDD

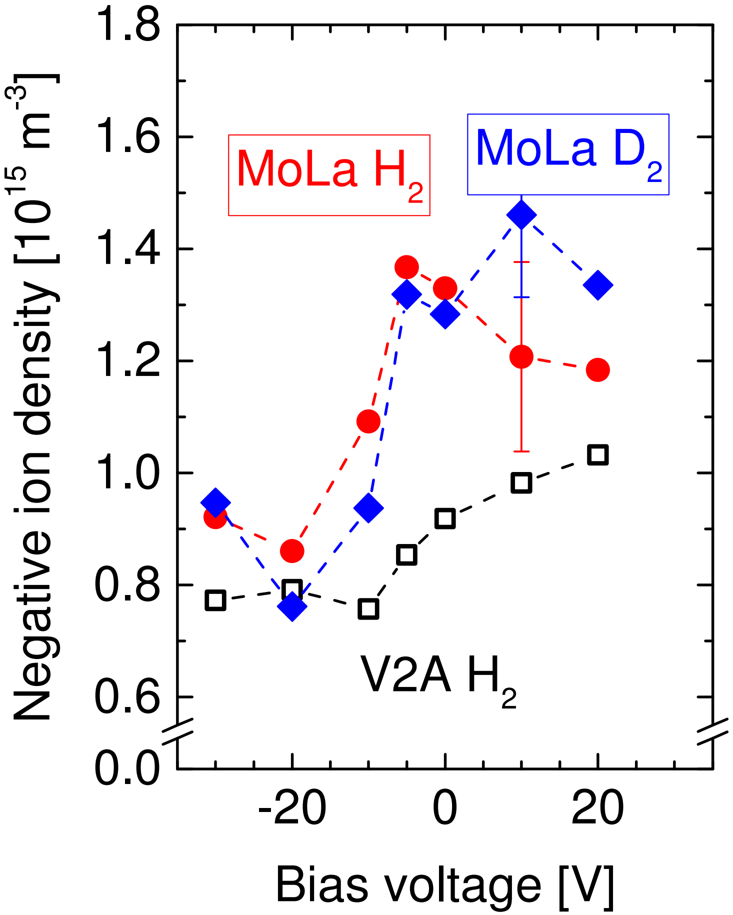


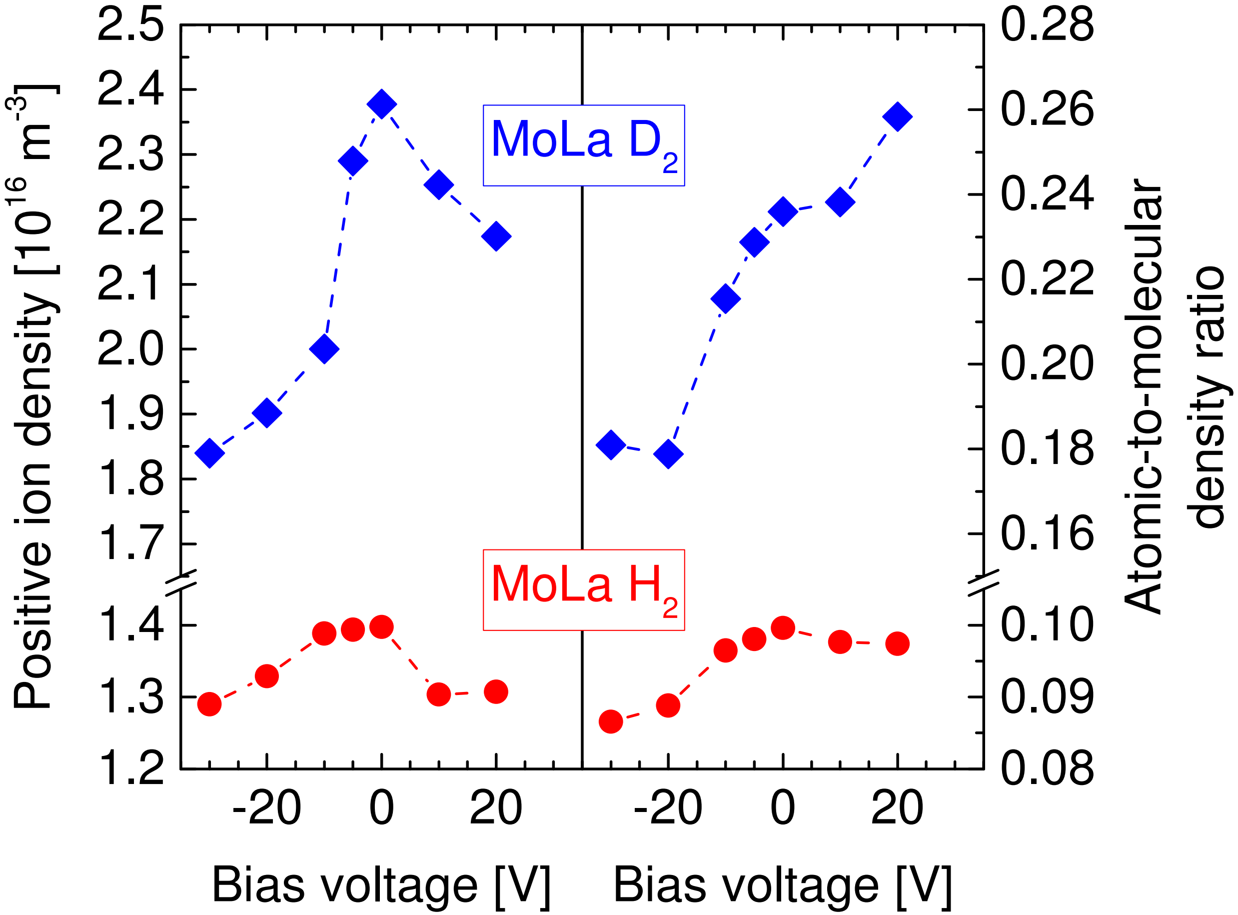


$H_2(\nu) + e \rightarrow H + H^-$ **DA vs. AD** $H^- + H \rightarrow H_2 + e$

- **V2A:** H^- volume formation: absolutely determined by $H_2(\nu)$ and H/H_2
  relative variation due to EEDF (T_e^{eff})
- **BDD:** enhanced volume formation expected → but **no enhancement measured**
  and **severe plasma-induced erosion detected**
- **LaB_6:** similar volume formation expected → but **enhancement measured** (χ < 3 eV)

Cs-free Materials – MoLa in H_2/D_2

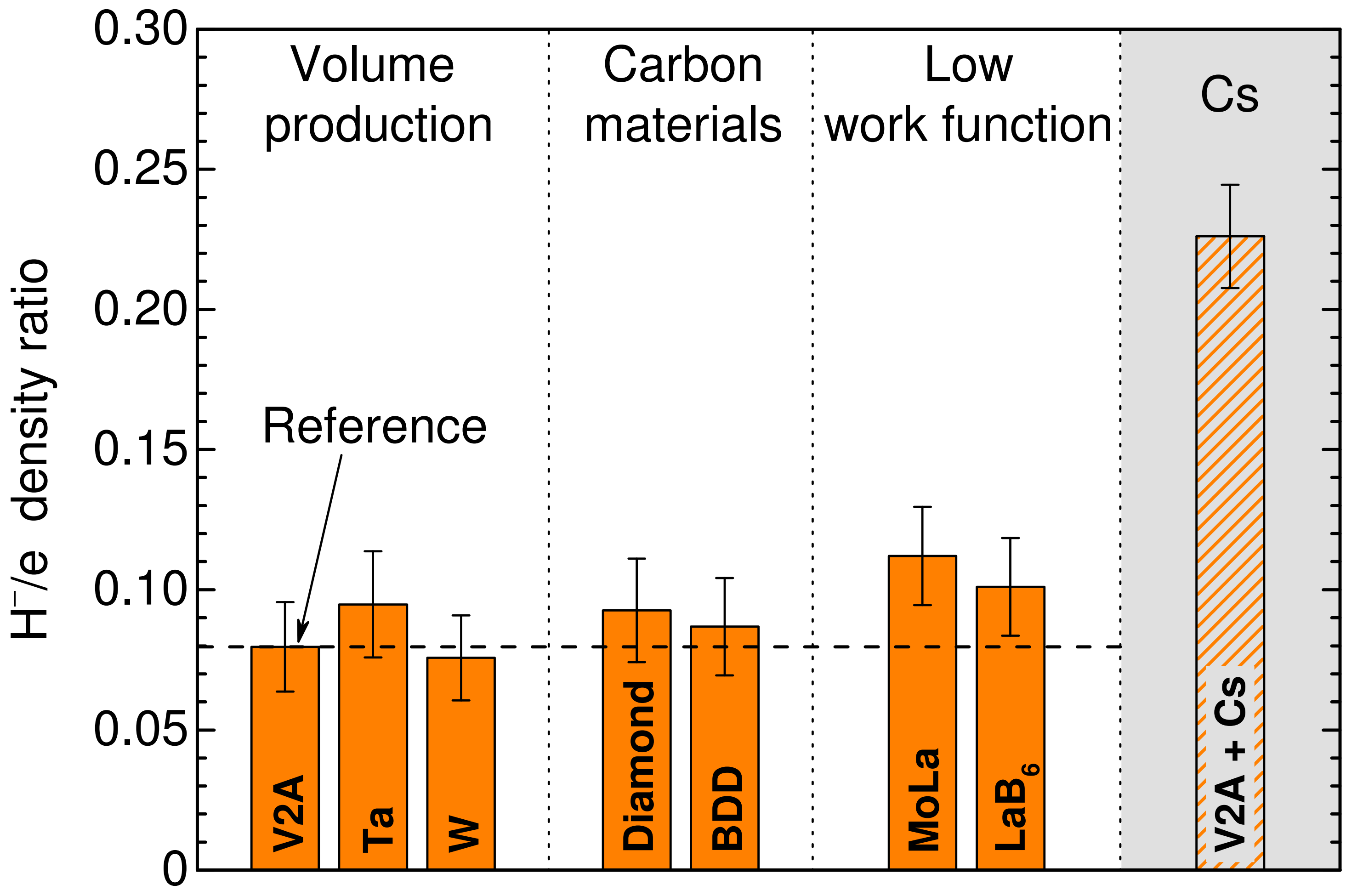




- **MoLa (χ < 3 eV): ≈ 60 % enhancement comp. to V2A**

- **D_2:** enhanced volume formation expected (n_e)
  enhanced volume destruction expected (D/D_2)
  } compensating → **Similar H^-/D^- density**

Cs-free Materials – Overview

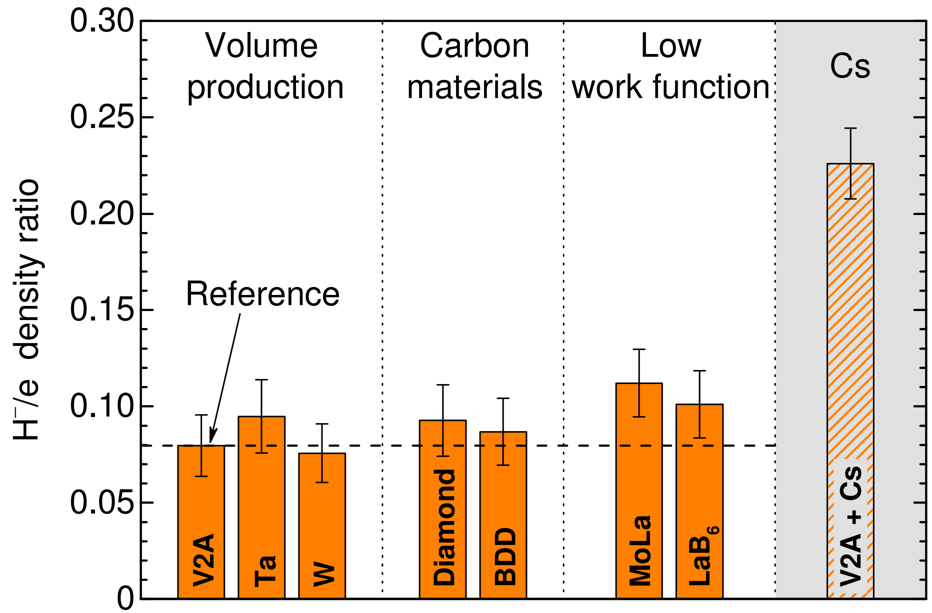


- No enhancement by: bulk Ta & W, diamond & BDD

- **Only low work function materials enhance beyond volume formation**
- **No material comparable to Cs → lowest work function**

Conclusion

- Cs-free materials investigated under
  - identical and
  - ion source parameters
- Compared to
  - pure volume formation and
  - caesiation



- No material comparable to Cs ($\chi_{bulk} \approx 2.1$ eV, increase by 150 %)
- Carbon materials show severe erosion (none of the other materials)
- Most promising: materials with inherent low work function (LaB_6, MoLa) ($\chi < 3$ eV, increase by ≈50 %)
- Comparable negative ion densities for H_2/D_2 operation