Characterization of various plasma reactors dedicated to nanoparticle functionalization

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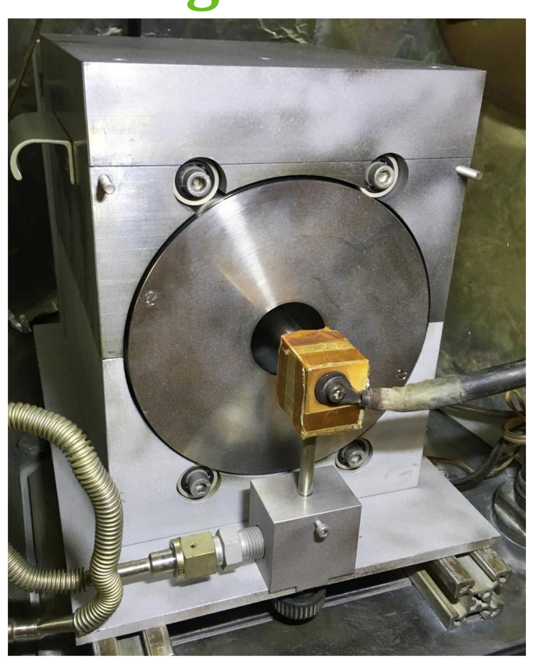
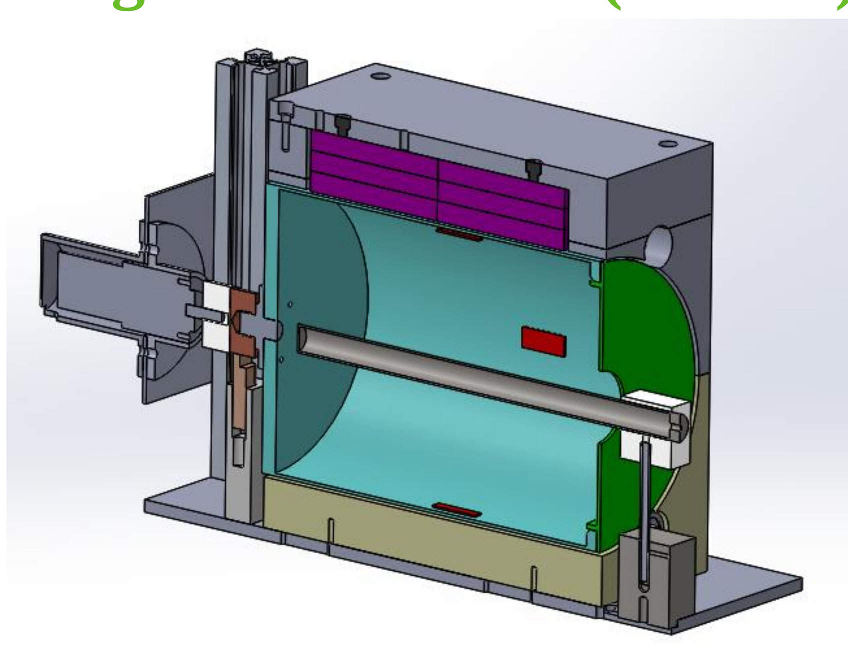
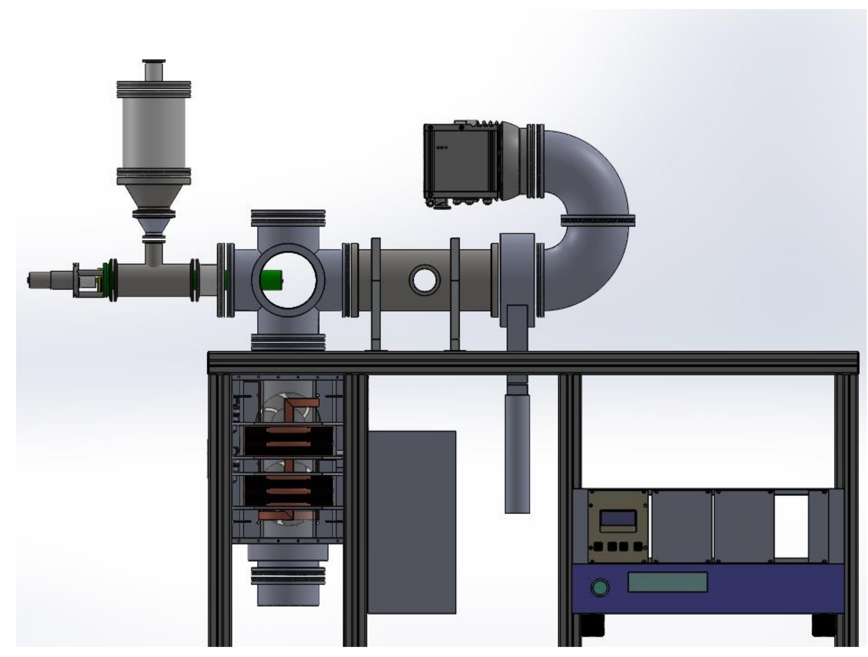
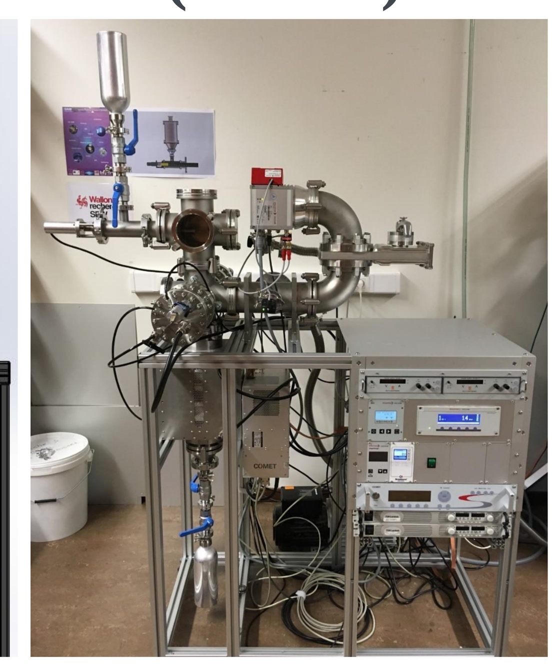
Introduction

The surface treatment of nanoparticles is an essential step in the synthesis of high added value polymer nanocomposite, to avoid nanoparticles agglomeration and create a strong bonding interface with the host matrix. Among existing methods, the deposition of plasma polymers has numerous advantages such as high versatility regarding the incorporation of a chemical functionality, little use of chemicals, simple apparatus, short process time and easy scale-up to mass production. In this work, we compare the efficiency of two homemade low-pressure plasma reactors dedicated to the treatment of nanoparticles.

Magnetron Rotating Drum Reactor (MRDR) *VS* RF Gravitational Reactor (RFGR)

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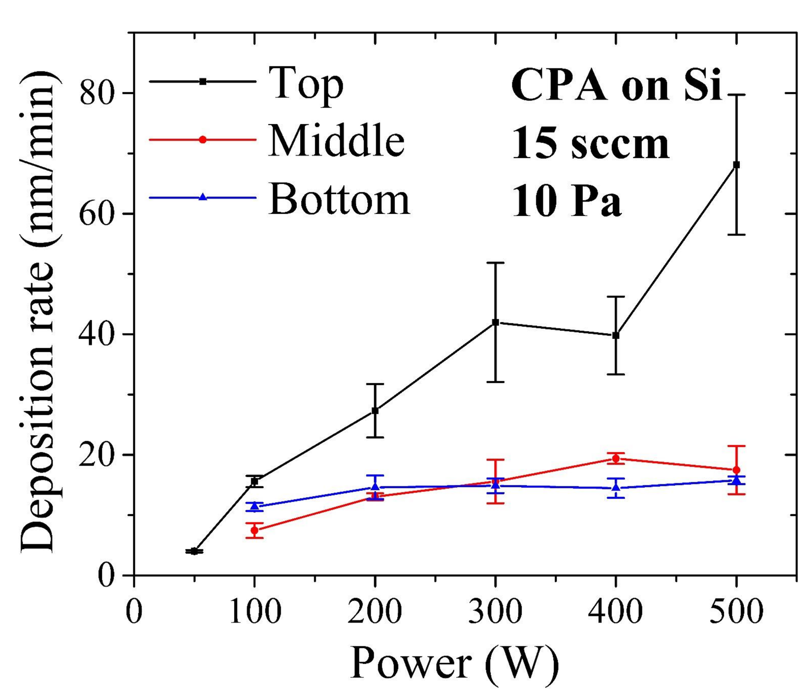
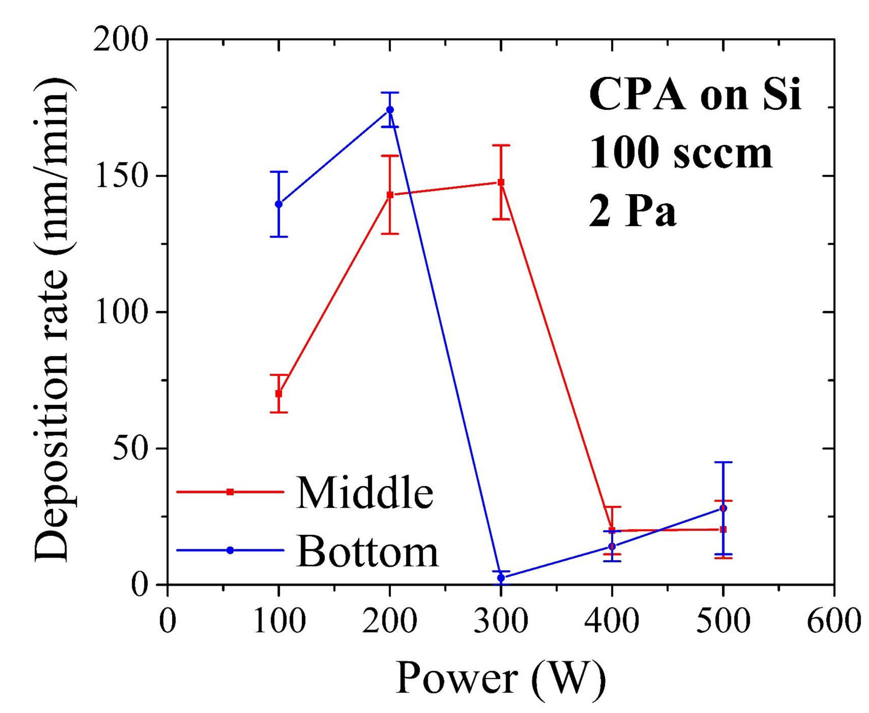
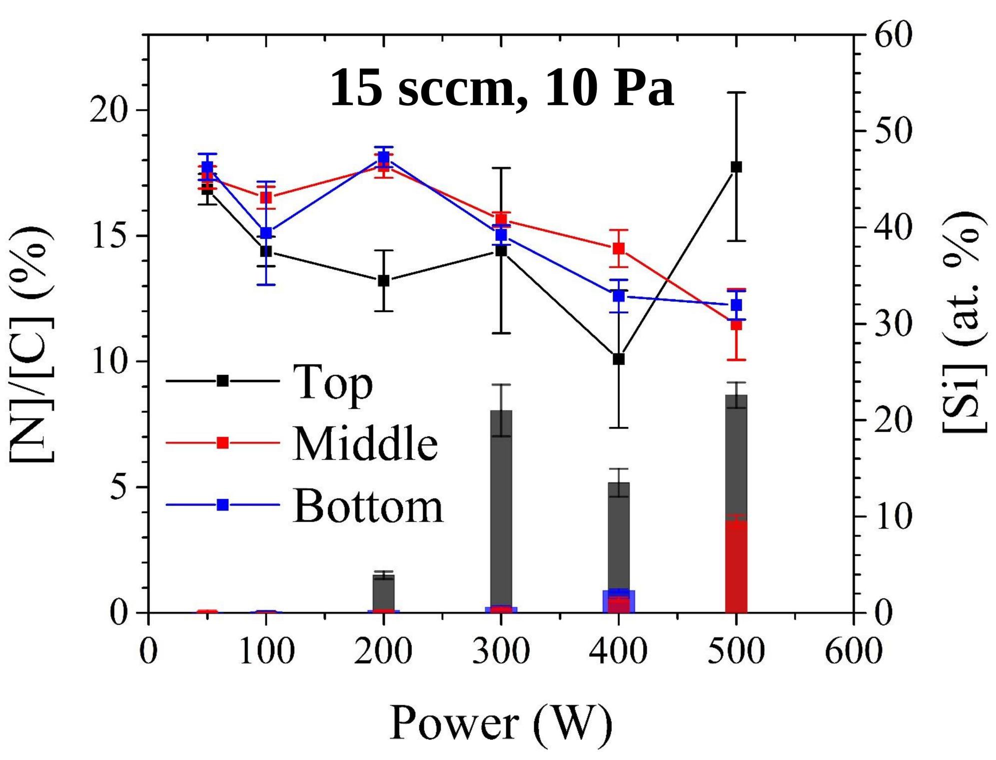


MRDR		RFGR
2.5 → 20 Pa	Pressure range	0.5 → 5 Pa
No restriction	Residence time in the plasma	~ 1 s / run
30 → 160 g/h	Maximal Production rate* (NPs density)	For 10 runs: 10 → 80 g/h
5 → 20 % / batch	Material loss* (Nature of NPs)	~ 3 % / run

* *The values given shall be regarded merely as indicative.* *(Depends on)*



Nitrogen incorporation depending on Position and Power

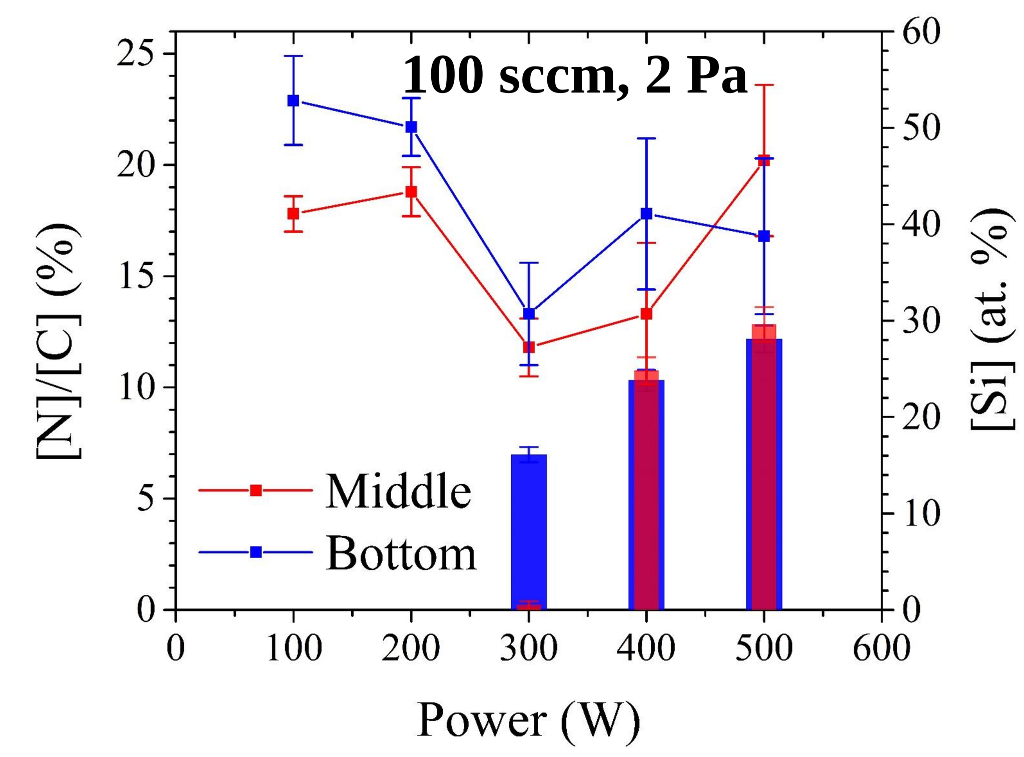


Cyclopropylamine-based PPF on Silicon wafer

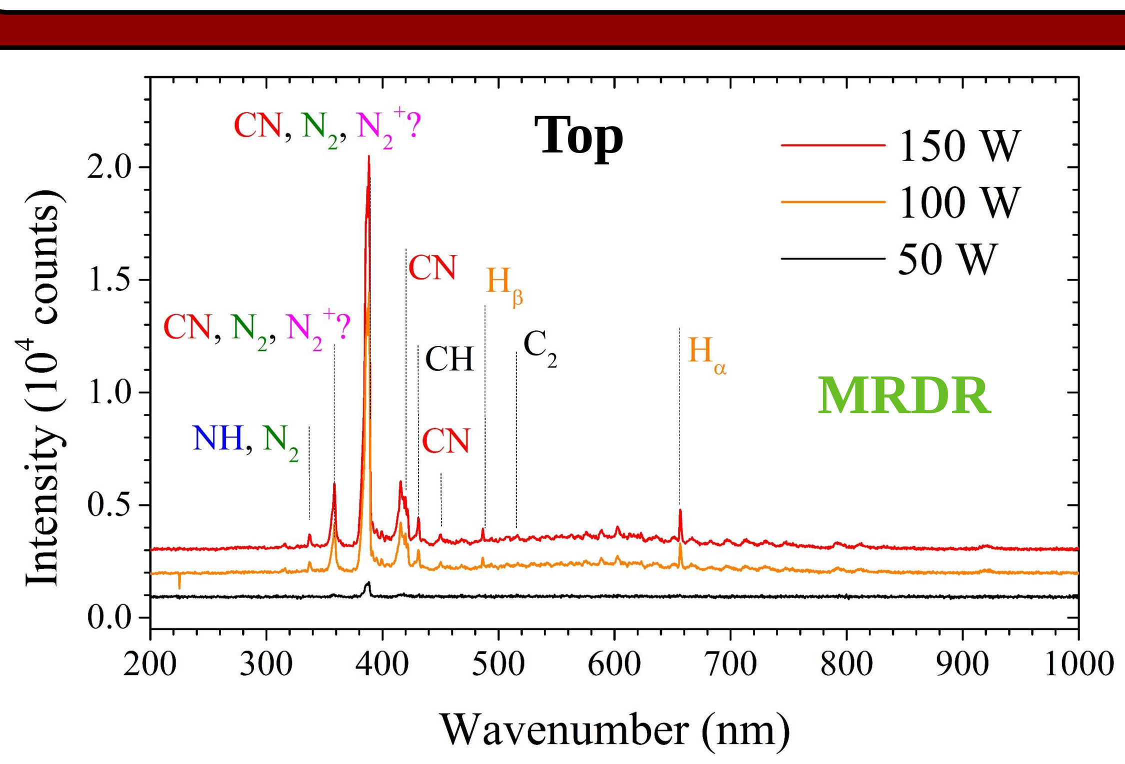
Strong gradients near magnets
- Higher deposition rates
- But also intense sputtering
⇒ Appearance of Si

Strong depletion of the monomer
- Above 300 W at middle position
- Above 200 W at bottom position
⇒ Drop in deposition rate
⇒ Appearance of Si

For both reactors, increasing the power reduces N incorporation
(Observation hindered by the possible formation of Si_3N_4 at high power)



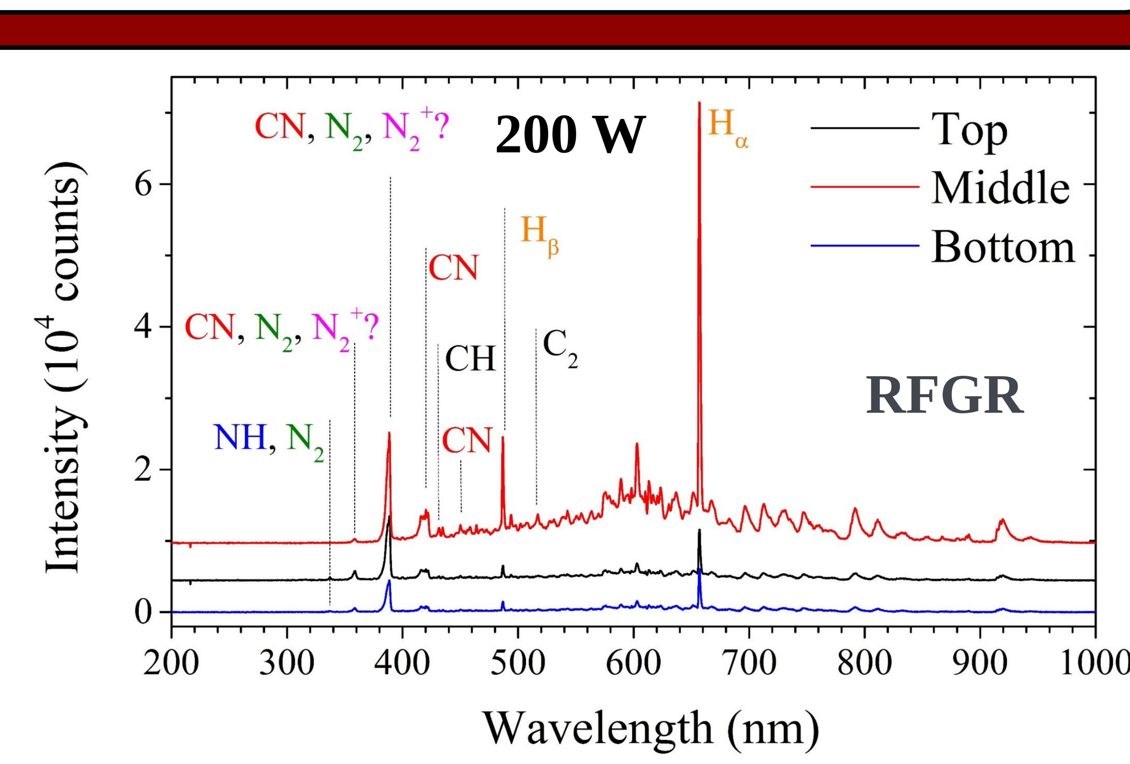
OES diagnostic



⇒ Strong influence of the position on plasma chemistry

⇒ Possibility to control the extent of fragmentation by varying plasma parameters.

⇒ Different fragmentation patterns depending on the reactor, revealing different physicochemical mechanisms in the gas phase and different surface reactions.



Conclusions and Prospects

→ The plasma polymerization of cyclopropylamine has been investigated in two plasma reactors dedicated to the surface functionalization of NPs.

→ Strong gradients (densities, temperatures, deposition rates, plasma and thin film chemistries) are observed in both reactors depending on the position.

→ Additional plasma diagnostic and thin film characterization are required to better understand the relationships between plasma parameters and thin film growth mechanisms.

→ The impact of nanoparticles on plasma properties needs to be investigated.

Wallonie
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