Modelling and simulation of Cl2 plasma and mixtures : Application to material etching

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Outline

- Plasma etching
- Kinetic modelling
- Cl_2 plasma
- Cl_2 plasma : Addition of Ar

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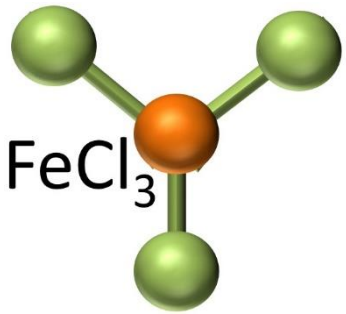
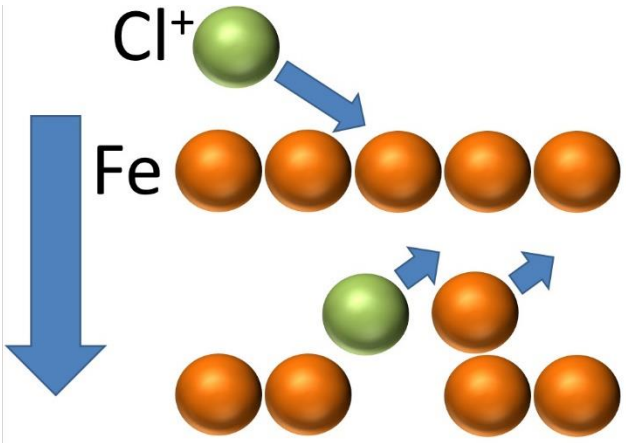
Plasma etching

Chemical etching : Creation of volatil molecules due to adsorption of reactive neutrals onto surface atoms



Good selectivity

Physical etching : Expulsion of surface atoms due to impact of energetic ions



Good anisotropy

3

Plasma etching

Plasma etching

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Cédric Doutriaux [2018]

Kinetic modelling : Global 0D model

Density balance equation

$$\frac{\partial n_i}{\partial t} = x_i \frac{Q}{V} - \sum_{i,l} k_{il} n_e n_i + \sum_{m,l} k_{ml} n_e n_m - \sum_{y,i,l} k'_{yil} n_y n_i + \sum_{r,t,l} k'_{rtl} n_r n_t \pm k_{s,i} n_i - \frac{n_i}{\tau_r}$$

Neutrality condition

$$n_e + \sum_i n_{-,i} = \sum_j n_{+,j}$$

→ Average Γ_i, n_i, n_e

Power balance equation

$$\frac{\partial}{\partial t}\left(\frac{3}{2} T_e n_e\right) = \frac{\eta P_{RF}}{V} - \frac{P_{ev} + P_{eiw}}{V}$$

→ Average T_e

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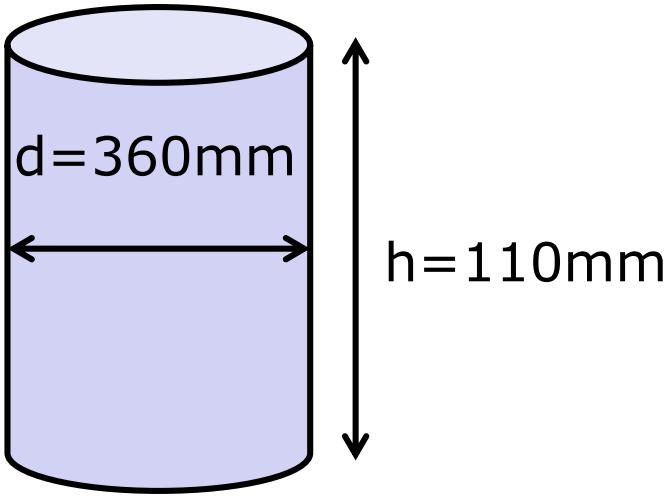
Cl_2 Plasma

Follow densities in Cl_2 plasma versus power, pressure and flow rate

Aim : From operating conditions provided by experiments, study their variations to be able to provided better operating conditions

Pression (mTorr)	Puissance (W)	Débit (sccm)
5-20 (Pas de 20)	100-1500 (Pas de 100)	20-100 (Pas de 20)

Simplified geometry of an ICP/RIE SENTECH



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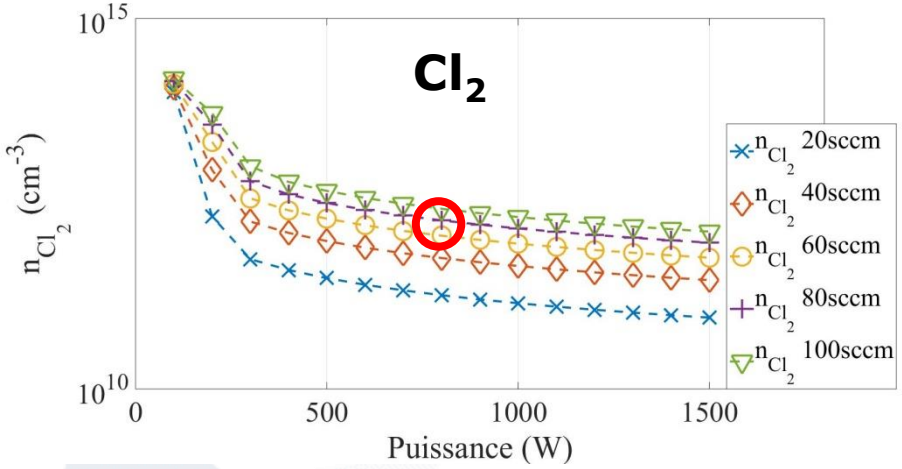
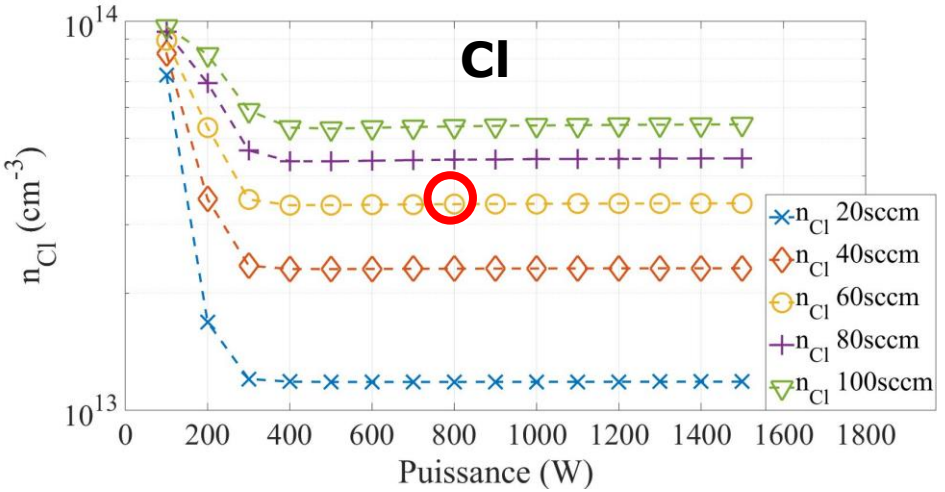
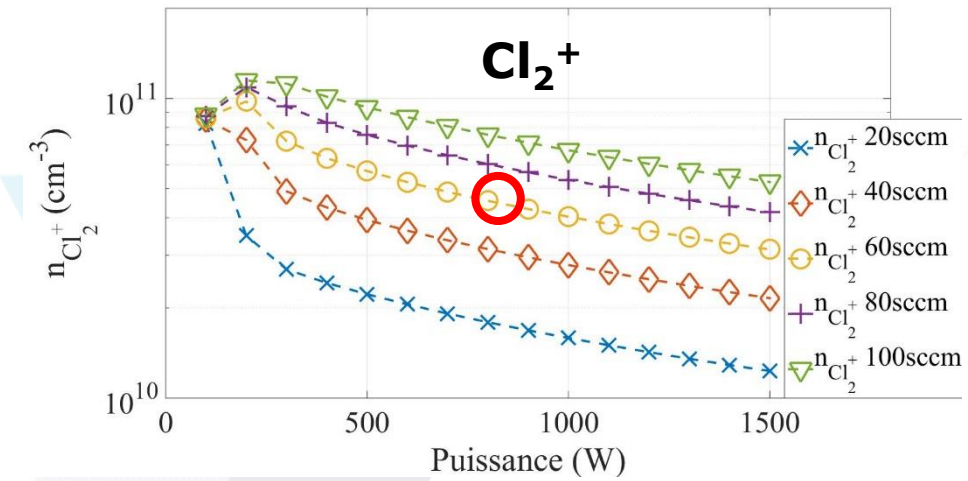
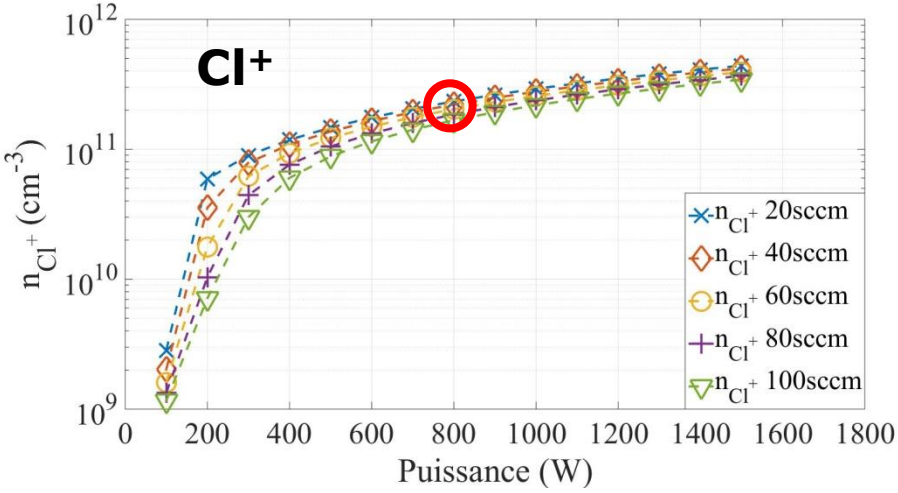
Cl_2 Plasma : Densities evolution 10mTorr









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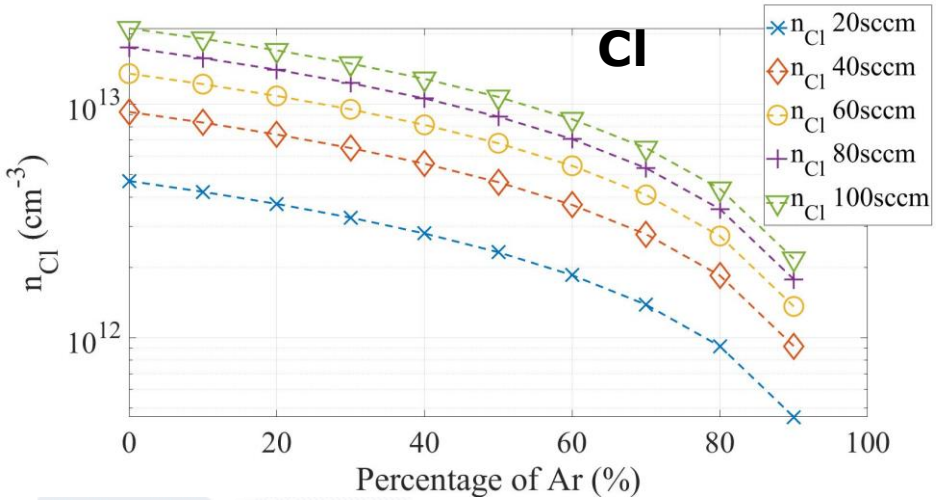
Cl_2 plasma : Conclusion

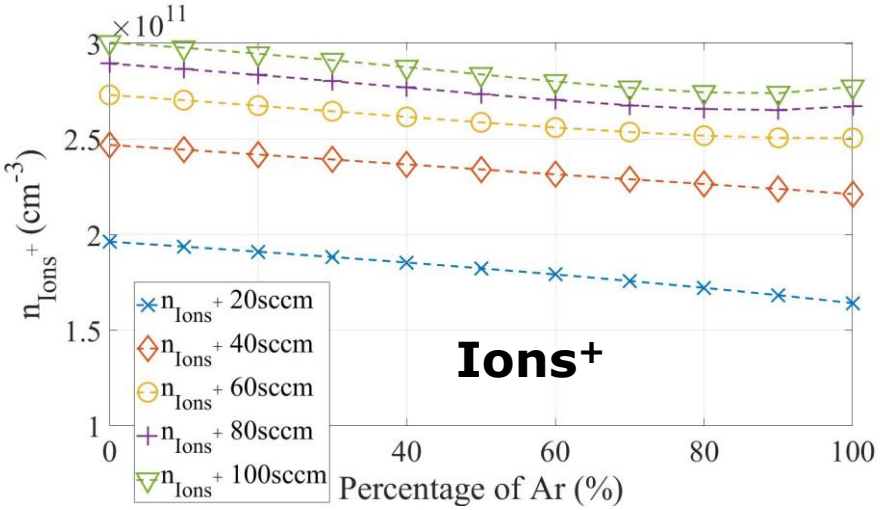
Cl_2 plasma has high dissociation rate in these operating conditions

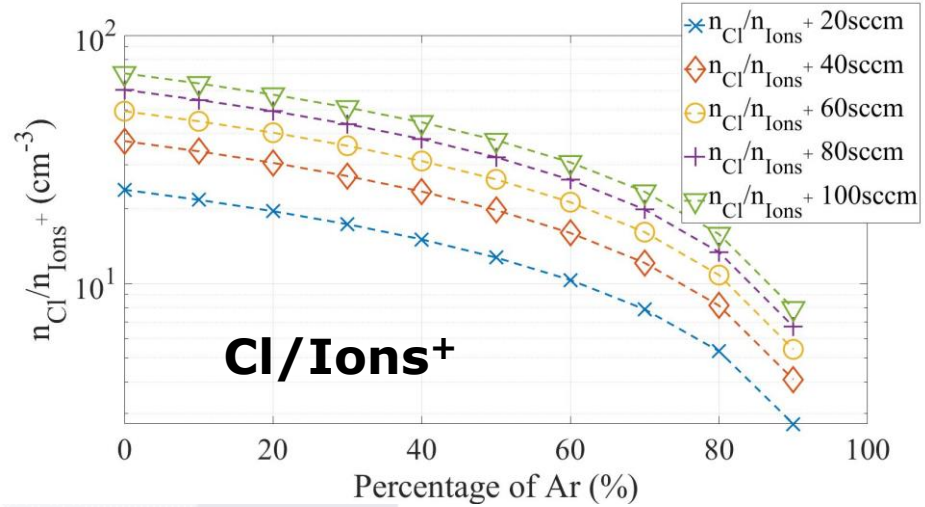
Increasing flow rate (100sccm) with moderate pressure (20mTorr) and low power (400W) allows to increase reactive neutral densities

Moderate flow rate (60sccm) and moderate pressure (20mTorr) associated to a high power (1200W) allows to increase positive ions densities

Cl_2 Plasma : Addition of Ar







Controlling ratio between chemical and physical etching without modifying other process parameters

Plasma modelling : Conclusion

Global kinetic modelling helps to study densities all over a large range of operating conditions

Not affected by reactor changes

Depending of the experiment to confirm the results

Simplified representation of a plasma

Acknowledgments

Thank you for your attention