

Argon Plasma simulations for students at Fontys University

Helger van Halewijn¹,

1. Fontys University of Applied Physics, Rachelsmolen 1, 5600 MA, Eindhoven, The Netherlands.

Introduction: At the Fontys University the Harrick Plasma Cleaner PDC-001 has been acquired for experiments on surface modifications. The cleaner / etcher can be filled with Ar, He, H₂, N₂ or air. The etcher runs typically at 1 Torr and 30 Watt input power. The frequency is 13.56 MHz.

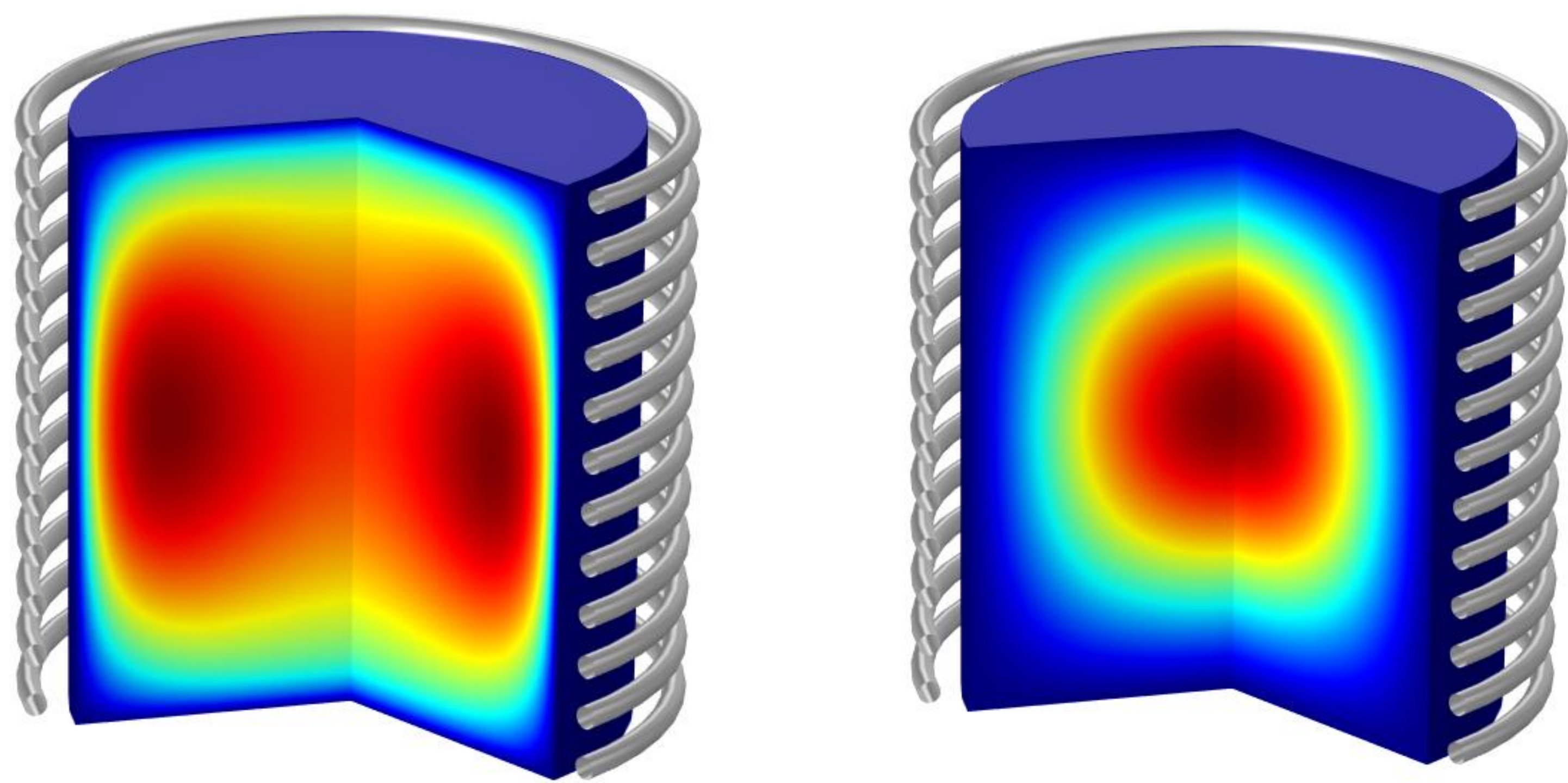


Figure 1. Left Excited Argon, Right Ionized Argon at 1 torr and 30 Watt coil power

Computational Methods: The Induced Coupled Plasma module is used to simulate the excited and ionized states of the gas. The transport settings include the calculation of thermodynamic properties. Then the Heat Transfer Module is coupled into the simulation. As an example the following Argon gas reactions are taken into account:

1. $e^- + \text{Ar} \rightarrow e^- + \text{Ar}$
2. $e^- + \text{Ar} \rightarrow e^- + \text{Ar}^*$
3. $e^- + \text{Ar}^* \rightarrow e^- + \text{Ar}$
4. $e^- + \text{Ar} \rightarrow 2e^- + \text{Ar}^+$
5. $e^- + \text{Ar}^* \rightarrow 2e^- + \text{Ar}^+$

In the study the frequency-transient method is used and under the study extensions independently the pressure and the power can be defined in an auxiliary sweep.

Results: The challenge for the students is to set-up a plasma simulation with COMSOL. Then determine the power handling of the system and ratio of excited species as a function of pressure and temperature. When the power input of the coils is 30 Watt the total surface heat source of reactions is 9 Watt. This means that approximately 30% of the power is lost through recombination at the wall of the reactor chamber.

As a second example hydrophobic plastic foils are introduced in the reactor for a treatment to convert it into an hydrophilic sheet. Students should measure the contact angle with water drops

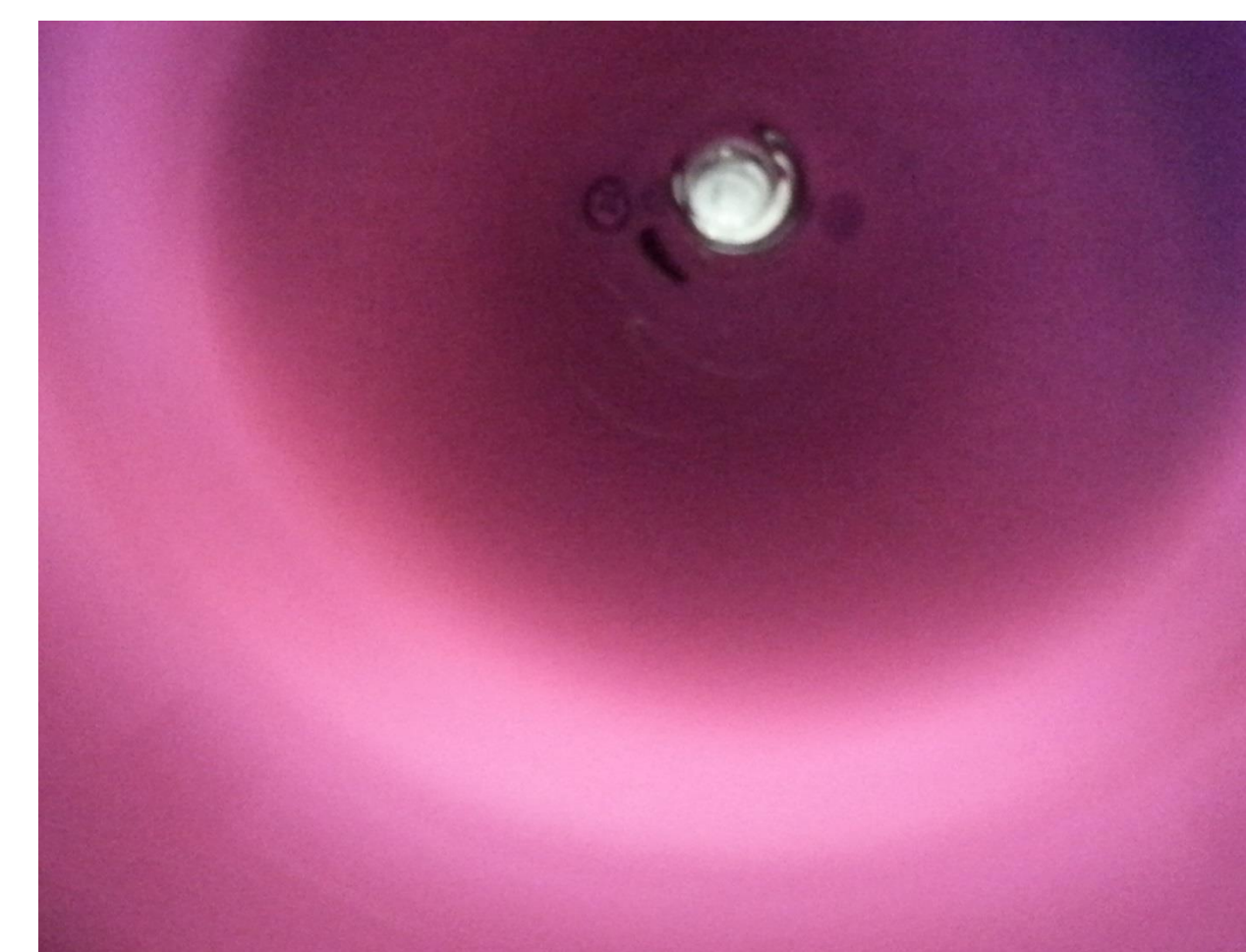


Figure 2. The plasma



Figure 3. Overview equipment

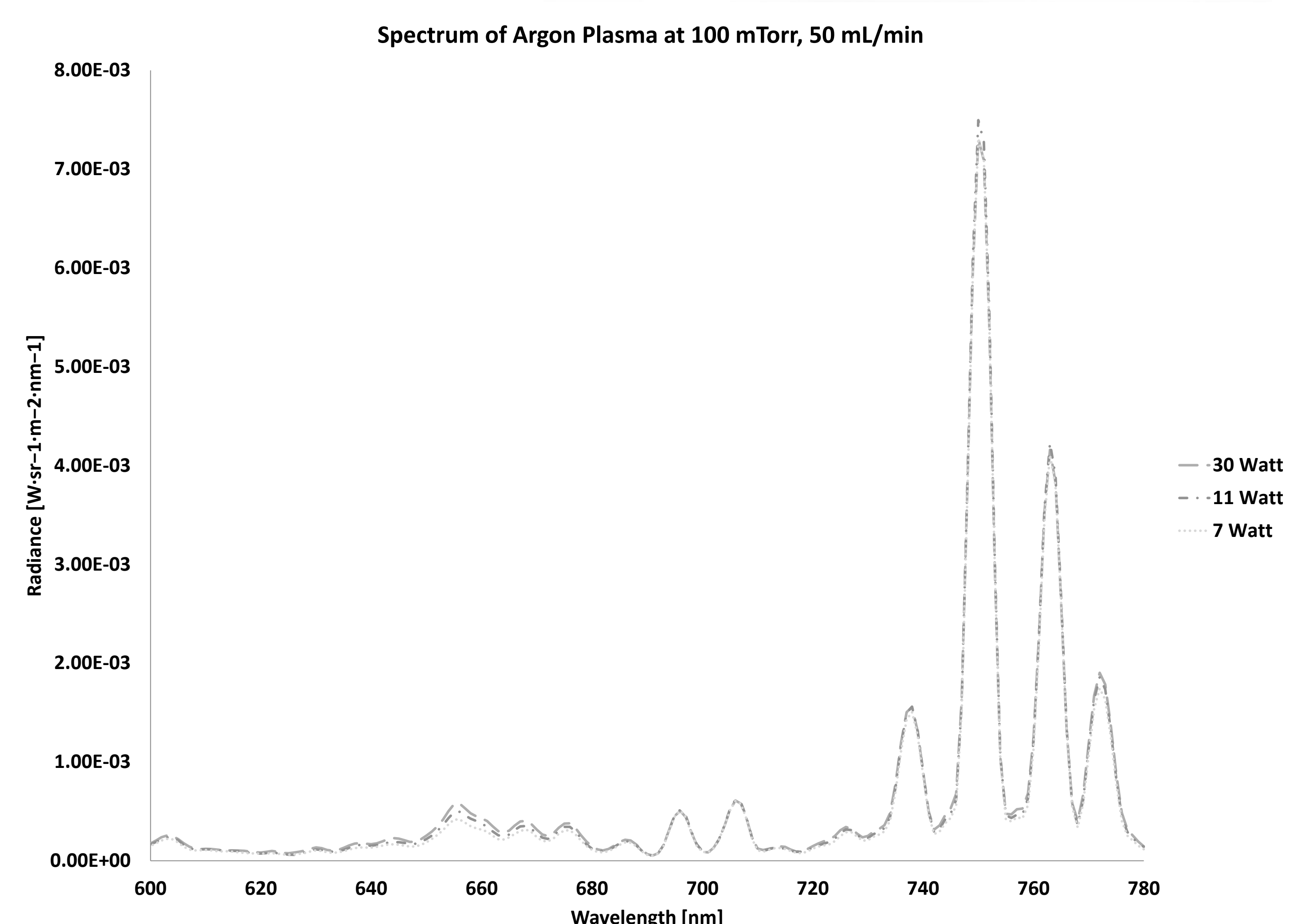


Figure 4. Measured spectrum of Ar-gas in reactor

Conclusions: The distribution of excited species in the simulations need to be tuned in the reactor. The system parameters are under investigation together with a parameter scan in COMSOL. We will run the simulations with other gases. Students should come up with a manual to simulate the gases in the reactor. Next year we will present detailed measurements in relation with the COMSOL results.

References:

1. N. Braithwaite, Introduction to gas discharges, Plasma Sources Sci. Technology (9) 2000.
2. L. Tong, Effect of Gas Flow Rate and Gas Composition in Ar/CH₄ Inductively coupled plasmas, 2011 Comsol Boston Conference.