# Micro Hollow Cathode Discharge in Ar/$Cl_2$ mixture as a VUV source for Cl-atom density measurements by resonance absorption

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In microelectronics manufacturing, $Cl_2$ based plasmas are widely used to etch materials. The etching rates are sensitive function of the Cl-atom flux impacting onto the surface, so that accurate measurements of the Cl atom density are required for optimizing the etching process [1]. However such measurements are still challenging and, up to now, only rough estimates of Cl atom density in the plasma are available [2]. Thus, the aim of the present work was to develop a VUV light source emitting on the resonance lines of Cl atom in order to perform direct measurements of the Cl atom density through resonance absorption spectroscopy. For good spatial resolution over a given line-of-sight, the source should be point-like. To be useful in the context of semiconductor manufacturing, it also must be compact and reliable.

In order to fulfill the above requirements, we used the emission of a micro hollow cathode discharge (MHCD) [3] operating in an Ar/$Cl_2$ mixture. The MHCD is made of a metal/dielectric/metal sandwich drilled with a hole 800 µm in diameter. One electrode is powered in DC mode through a ballast resistor of 400kΩ, while the other is directly grounded. The MHCD is operated in the so-called normal mode [4] in which the discharge largely spreads over the cathode surface and can reach diameter as large as 1 cm. However, the emission intensity of the plasma confined inside the hole is one order of magnitude higher than the intensity of the plasma spreading on the back-side of the cathode. When viewed from the anode side, the micro-plasma emission appears as an intense point-like (800 µm in diameter) source which can be easily imaged on the entrance slit of a VUV monochromator after passing through the etching reactor.

Analyzed with a 50 cm focal length VUV spectrograph, the emission spectra from the MHCD discharge shows the presence of seven strong Cl-atom lines in the spectral range 130-140 nm. The chlorine partial pressure and the total pressure dependence of the intensity of these lines have been studied at different discharge currents. As it will be discussed in detail, only three of these 7 lines, at wavelengths above 137.5 nm can be used for an accurate resonance absorption measurement. The 4 other lines being subjected to a strong auto-absorption within the MHCD plasma. For the best excitation conditions of the useable lines, a gas temperature of 800K is deduced from the intensity distribution in rotational lines of the second positive system of nitrogen, $N_2$ being present as an impurity. As a result, we have concluded that under these experimental conditions, the Doppler broadening is dominant and the spectral profile of the lines can be represented by a Gaussian, with a FWHM value of 4.7 $10^{-4}$ nm.

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