# Nitrogen-containing plasma polymer nanoparticles produced by means of a gas aggregation cluster source

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Nitrogen-containing plasma polymer particles were prepared by means of a gas aggregation cluster source with special attention paid to finding the correlation between the plasma composition and the properties of the particles. It has been shown that the stability and reproducibility of the deposition rate of the particles are significantly dependent on the pressure in an aggregation chamber. On the other hand, the chemical composition of the particles, particularly the nitrogen concentration, can be tuned by the amount of $N_2$ in the working gas mixture.

## 1. Introduction

Generation of polymer particles with tuneable size distribution and chemical composition is of high scientific interest. Low-temperature plasma is known to be capable of production particles in the gas phase via plasma polymerization processes. Recent years witnessed the successful application of Gas Aggregation cluster Sources (GAS) for the production of C:H, C:H:N:O, C:F and C:H:Si:O particles. Little is known however about the processes that occur in the plasma during the particle formation. The main aim of this work was to develop a GAS that allows the in-situ diagnostics of the plasma chemistry within the aggregation zone.

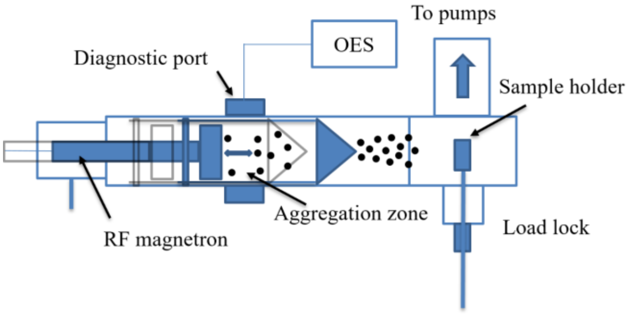


**Fig. 1.** Scheme of the experiment

## 2. Experimental

The GAS was based on a 3-inch RF magnetron with a 3-mm thick nylon 6.6 target. The aggregation zone was created by attaching a conical lid with an orifice (∅2 mm) 10 cm opposite to the magnetron. The GAS was constructed to allow moving the entire assembly of the magnetron and the orifice with respect to the static diagnostic ports while maintaining the length of the aggregation zone unchanged (Fig. 1). OES and Langmuir probes were connected to the diagnostic port to monitor the plasma parameters in dependence on the distance from the magnetron. Ar or different Ar/$N_2$ mixtures were used as working gases. The magnetron power was varied from 20 to 80 W.

## 3. Results

The deposition parameters were found to produce the particles with the size ranging from 220 nm to 300 nm. The addition of nitrogen into the GAS enhanced the emission from the nitrogen-containing species (Fig. 2) which was accompanied by an increase of the nitrogen content in resultant particles.

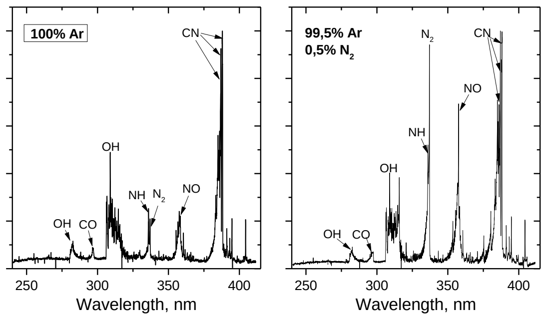


**Fig. 2:** Optical emission spectra obtained in Ar (left) and with the addition of 0.5 % of $N_2$ (right).

The ratio between the emission intensity of different species was found to be stable along the axial distance from the magnetron which may point at the longitudinal invariability of the plasma polymerization processes. Langmuir probe measurements showed a decrease of the electron concentration when particles appeared in the gas phase.

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