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Morphological and spectral features of interstellar carbon dust analogues deposited in high power regime DBD

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In recent years, particle synthesis using plasma based techniques became an appropriate tool to obtain laboratory analogues of carbon interstellar dust. Thus it is possible to deposit carbon based films or powders on various substrates, with morphological and spectral features similar to the radio telescope observations or dust collectors on-board the space probes. We discuss here the possibility of employing the high power regime DBD in helium-hydrocarbon gas mixtures to synthetize carbon based dust analogues.

1. Introduction

Carbonaceous and silicate dust grains represent around 1 % of the interstellar medium (ISM) total mass. Surface reactions on grains or on ices formed around the grains play important roles in many astrophysical or astrochemical processes. Thus, it is of interest to synthetize nanometer and micrometer sized solid particles, showing morphological and spectral similarities to the ones observed in ISM. Various spectral, morphological or structural criteria can be used to discuss the similarity degree of synthetic products to data from space and Earth based instruments. Plasma particle synthesis represents a good solution to obtain in controlled conditions, showing reproducible chemistry, size distribution and morphological features. We present here results concerning the high power regime DBD deposition of carbon based particles.

2. Experimental

The helium / hydrogen (1%) / hydrocarbon (C_nH_{2n+2}, n= 1 - 4) (10%) containing plasma at atmospheric pressure was generated using a barrier discharge in parallel plate configuration. The discharge was excited using short duration positive voltage pulses, 5.7 kV amplitude, 400 ns pulse width, 100 ns rise time and 1 kHz repetition frequency. The electrode assembly was hosted by a stainless steel chamber, vacuumed prior all experiments. The discharge operation was monitored by electrical, gas temperature, emission spectroscopy measurements and fast imaging. The exit gas from reactor, sampled in vacuumed gas cells with NaCl windows, was analysed by FTIR to identify the molecular composition. The carbonaceous deposits were investigated by electron microscopy (SEM) and various spectroscopic methods (UV-VIS, FTIR, Raman, XPS).

3. Results and discussion

By admixing H_2 and CH_4 to the helium main gas, plasma electrical parameters vary. The amplitudes of both discharge current peaks was around 8 A during the HV pulse rise and fall times. This corresponds to 8 kW power peak and 20 mJ energy per pulse, implying a high power regime as compared with classic DBDs.

The deposits shows spectral features similar to astrophysical products (e.g. the 3.4 μm, 6.8 μm, 7.2 μm bands) and the morphology as revealed by SEM shows the aggregation of sub-micrometric grains to form micrometer sized solid particles.

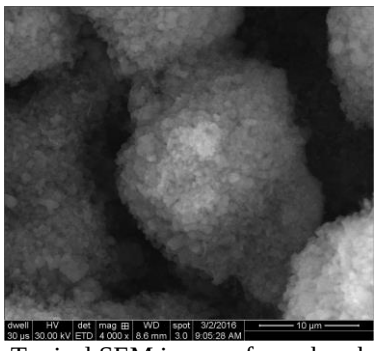

Figure 1. Typical SEM image of a carbon based dust particle obtained in $He/H_2/CH_4$ DBD.

4. Conclusion

The experimental results show the potential of high power regime DBD in deposition of carbon based dust particles and their subsequent classifications as interstellar dust analogues.

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