Synthesis of titanium particles by RF atmospheric plasma jet: continuous mode vs. pulsed mode

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By controlling the particle synthesis process one can tailor specific particle's properties, namely size, shape, composition, surface area, etc. In our study titanium particles were obtained using a radio-frequency (RF) plasma jet that operates at atmospheric pressure, in continuous or pulsed mode.

Energy Dispersive X-ray Spectroscopy (EDS) investigations, optical and Scanning Electron Microscopy (SEM) analyses reveal that titanium spherical nano or micro-particles were deposited. The particle's structure, as investigated by Transmission Electron Microscopy (TEM), presents a surface oxide layer. The size, shape and density of the particles is influenced by the plasma parameters (power, frequency or duty cycle).

1. Introduction

In this contribution, we report the use of a RF atmospheric plasma jet to produce titanium particles by means of a gas-phase plasma method. It was found that adjusting the operating plasma mode it is possible to obtain titanium particles with sizes ranging from few hundreds of nm up to few microns. Moreover, tailoring the plasma parameters (power, frequency, duty cycle) particle's characteristics (size, shape and density) are changed drastically.

2. Experimental details and results

2.1. Experimental set-up

The schematic drawing of the set-up is presented by Figure 1 and was described in our previous papers [1].

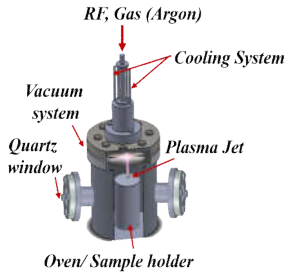

Fig. 1. Experimental set-up for titanium particles synthesis at atmospheric plasma jet

We highlight that titanium powered electrode, connected to a radiofrequency (RF) 13.56 MHz generator, is the starting material for the titanium particles. The particles were obtained using argon (1000 sccm and 5N purity).

Other parameters were: 20 mm the distance between the electrodes, 6 mm the distance between nozzle and Si substrate, 1 h exposure time, 70-200 W power and 1040 mbar operating pressure. When working in pulsed mode frequencies between 1-10 kHz and duty cycles of 20 up to 80% were used.

2.2. Results and conclusions

Spherical non-agglomerated titanium particles are obtained. Their size varies between 200 nm and ~3 μm and have a surface oxide surface layer.

In continuous plasma mode, the synthesis of titanium particles starts at 70 W and their size increases with increasing the RF power (Figure 2).

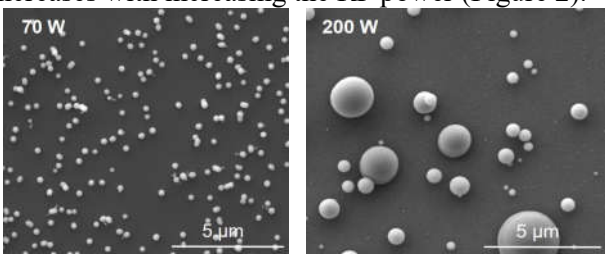

Figure 2. SEM image of titanium particles for 70 W (left) and 200 W (right, obtained in continuous plasma mode).

For pulsed mode, uniform size titanium particles are noticed mostly for high duty cycles (80%) and high frequency (10 kHz).

3. References

[1] A. Lazea-Stoyanova *et. al*, Plasma Processes and Polymers, Vol. 12, Issue 8, 705-709, 2015.

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