Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2596** Type: **Poster (Non-Student) / Affiche (Non-étudiant(e))**

14 - DC magnetron discharge used for nanoparticle growth: comparison of particle- in-cell simulations with experimental measurements

Tuesday, 4 June 2019 16:45 (2 minutes)

1. Introduction
The formation of nanoparticles (NP) in glow discharges has been for a long time a subject of high interest. In radio-frequency (RF) discharges, NP growth and its effect on discharge parameters have been studies using reactive
[1,2], and by sputtering of the electrodes [3]. In direct-current (DC) sputtering glow discharge, NP formation, dynamics and transport has also been studied using different cathode materials [4-8].
Since the mid-1990's, RF and DC magnetron-sputtering aggregation sources are commonly used to produce metal nanoparticles [9, 10]. They normally consist of a high-pressure plasma chamber connected to a low pressure expansion chamber in which a beam of NP can be filtered and collected. NPs are formed in the high-pressure side of the MS-AS by cathode sputtering. However, very few studies are devoted to the characterization of the magnetron plasma in which NPs are growing and the link between plasma parameters and NP growth dynamics.

2. Experimental setup
The experiments were performed in an argon DC unbalanced magnetron discharge having a 3"diameter tungsten cathode. The cathode was facing a grounded anode and the inter-electrode distance could be changed from 5 cm to 10 cm. Either two glass half-cylinders or two stainless steal half cylinders were used to confine the plasma. A 1 cm gap was kept between them for optical diagnostics and radial Langmuir probe measurements. An argon pressure between 10 Pa and 40 Pa (5 sccm gas flow) was set during the experiments. The discharge system was contained in a cylindrical vacuum chamber of 30 cm diameter and 40 cm length. A regulated power supply was used to bias the cathode. The discharge current was kept at a constant value (from 100 mA to 500 mA). Under the chosen operating conditions, the cathode was sputtered and tungsten NPs could be grown.

3. Particle-in-cell simulations
The simulation were performed using the VSIM software from TechX corporation [11]. 2D3V simulations in cylindrical geometry were preformed. The simulation box was cut in 512×512 cells. Dirichlet boundary conditions were used for the cathode (V=Vbias) and the anode (V=0 V), For the side wall, Dirichlet boundary condition were used to simulate the metallic cylinder (V=0 V). For the glass cylinder a dielectric was added to the simulation.The nominal density was set to 1012 cm-3 and the particle weight was variable. A time step of 10-12 s was used and the simulations were run for a few millions time steps until equilibrium was reached.

4. Results
The simulated potential and density profiles were compared to experimental measurements. The influence of the sputtered atoms on the discharge properties were also investigated. A particular attention is given to the influence of the sputtered metal on the electron temperature. Results are correlated to NP growth dynamics.

References

[1] M. Cavarroc, et al., Phys. Rev. Lett. 100, 045001 (2008).
[2] I. Stefanovic, N. Sadeghi, and J. Winter, J. Phys. D: Appl. Phys. 43, 152003 (2010).
[3] D. Samsonov and J. Goree, Phys. Rev. E 59, 1047 (1999).
[4] G. M. Jellum and D. B. Graves, J. Appl. Phys. 67, 6490 (1990).
[5] C. Arnas, et al. , Phys. Plasmas 20, 013705 (2013).

[6] Kishor Kumar K., L. Couëdel, and C. Arnas, Phys. Plasmas 20, 043707 (2013).
[7] L. Couëdel, Kishor Kumar K., and C. Arnas, Phys. Plasmas 21, 123703 (2014).
[8] S. Barbosa, et al., J. Phys. D: Appl. Phys. 49, p. 045203 (2016).
[9] H. Haberland, et al., J. Vac. Sci.Technol. A 12, 29250 (1994).
[10] T. Acsente,et al., Mat. Lett. 200, 121 (2017).
[11] C. Nieter, and J. R. Cary, J. Comp. Phys. 196, 448 (2004)

Primary author: Prof. COUEDEL, Lenaic (University of Saskatchewan/CNRS)

Co-authors: Dr ARNAS, Cecile (CNRS, Aix-Marseille Univ., PIIM); Ms CHAMI, Alebia (CNRS, Aix-Marseille Univ, PIIM)

Presenter: Prof. COUEDEL, Lenaic (University of Saskatchewan/CNRS)

Session Classification: DPP Poster Session & Student Poster Competition Finals (7) | Session d'affiches DPP et finales du concours d'affiches étudiantes (7)

Track Classification: Plasma Physics / Physique des plasmas (DPP)