C1-O-002402

PLASMA PARAMETERS OF A PULSED HIGH-CURRENT LOW-VOLTAGE NON-SPUTTERING MAGNETRON DISCHARGE IN LIGHT GASES*

A.V. KAZIEV[1,2], D.V. KOLODKO[2], N.P. ORLOV[1]

[1]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow, Russia
[2]Fryazino Branch of Kotel'nikov Institute of Radio Engineering and Electronics RAS, Fryazino, Russia

Nowadays, a lot of practical applications—such as material etching; electric propulsion (plasma thrusters); material testing under high thermal and plasma loads—demand having efficient sources of highly ionized metal-free plasma. It could be convenient to utilize commercially available high-power impulse magnetron sputtering (HiPIMS [1]) technique for this purpose. However, originally HiPIMS is being used for coating deposition and thus in its conventional form is not suitable for generating plasma free of metal species. The usage of light working gas (hydrogen or helium) can significantly reduce the sputtering effects and turn this type of discharge into highly efficient generator of metal-free plasmas.

Depending on operating conditions (including pulse duration), it is possible to transform long HiPIMS regime (L-HiPIMS) into the non-sputtering low-voltage mode at the same power level. This mode is known as non-sputtering magnetron discharge (NSMD) [2–4]. Introducing hydrogen or helium into NSMD might result in high density plasma generation with extremely low cathode material erosion rate.

In this study, the operation of millisecond-scale non-sputtering discharge in hydrogen and helium has been examined. The pulse duration was around 1 ms, and the maximum pulse power was around 80 kW. The plasma parameters were monitored with an electric probe. The optical emission spectra from plasma were recorded synchronously with each pulse by AvaSpec ULS2048 spectrometer. Typical waveforms of discharge voltage and current together with probe current are presented in Fig. 1.

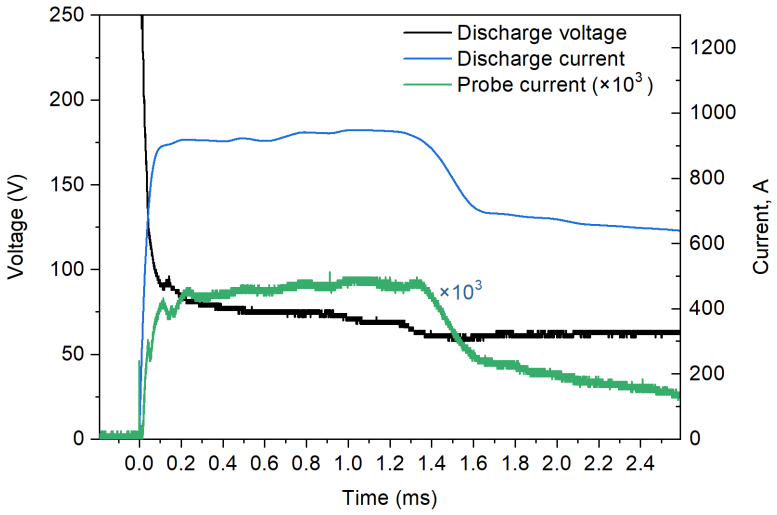

Fig.1. Discharge current and voltage traces together with probe current waveform (H_2, 2 Torr).

The use of the pulsed non-sputtering modes in hydrogen and helium enables achieving non-constricted plasmas with high density and no traces of optical emission lines corresponding to the species of cathode or anode materials.

REFERENCES

[1] J.T. Gudmundsson, N. Brenning, D. Lundin, U. Helmersson, "High power impulse magnetron sputtering discharge," J. Vac. Sci. Technol. A, Vol. 30, Article Number 030801, 2012.

[2] G.V. Khodachenko, D.V. Mozgrin, I.K. Fetisov, T.V. Stepanova, "Nonsputtering impulse magnetron discharge," Plasma Phys. Rep., Vol. 38, P. 71–78, 2012.

[3] A.V. Kaziev, "Cathode sheath processes in a non-sputtering magnetron discharge," Vacuum, Vol. 158, P. 191–194, 2018.

[4] T.J. Sommerer, S.C. Aceto, J.F. Trotter et al. "Operating modes of a magnetized cold cathode plasma in helium 50–6400 mTorr," J. Phys. D: Appl. Phys., Vol. 52, Article Number 435202, 2019.

* The work was supported by the grant of the Russian Federation President (MK-4445.2022.4).