[28-1]	15:50-16:20	**[Invited][28-1] Tailoring Ultra-low Friction Surfaces at Nanoscale** Tomas POLCAR[1,2,*] 1 Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, Prague 6, Czech Republic 2nCATS, University of Southampton, Highfield Campus, SO17 1BJ, UK
[28-2]	16:20-16:40	**[28-2] Capacitively Coupled Radio-frequency N2 Discharges at Low Pressures** L. MARQUES[1,2,]*, L. L. ALVES[1], C. D. PINTASSILGO[1,3], N. CARRASCO[5], L. BOUFENDI[4] and G. CERNOGORA[5] [1] Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade Técnica de Lisboa, 1049-001 Lisboa, Portugal [2] Centro de Física da Universidade do Minho, Universidade do Minho, 4710-057, Braga, Portugal [3] Departamento Engenharia Física, Faculdade Engenharia, Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal [4] GREMI Université d'Orléans BP 6744 - 45067 Orléans France [5] LATMOS-UVSQ-CNRS 11 Bd d'Alembert 78280 Guyancourt, France
[28-3]	16:40-17:00	**[28-3] Visualization of Plasma Currents** Byungwhan KIM[*] and Donghwa JUNG *Department of Electronics Engineering, Sejong University, Seoul 143-747, Korea

28. Plasma Diagnostics II		
Chair: Osamu SAKAI (Japan)		
[28-1]	15:50-16:20	**[Invited][28-1] Tailoring Ultra-low Friction Surfaces at Nanoscale**
		Tomas POLCAR[1,2,*] 1 Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, Prague 6, Czech Republic 2nCATS, University of Southampton, Highfield Campus, SO17 1BJ, UK
[28-2]	16:20-16:40	**[28-2] Capacitively Coupled Radio-frequency N2 Discharges at Low Pressures**
		L. MARQUES[1,2,*], L. L. ALVES[1], C. D. PINTASSILGO[1,3], N. CARRASCO[5], L. BOUFENDI[4] and G. CERNOGORA[5] [1] Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade Técnica de Lisboa, 1049-001 Lisboa, Portugal [2] Centro de Física da Universidade do Minho, Universidade do Minho, 4710-057, Braga, Portugal [3] Departamento Engenharia Física, Faculdade Engenharia, Universidade do Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal [4] GREMI Université d'Orléans BP 6744 - 45067 Orléans France [5] LATMOS-UVSQ-CNRS 11 Bd d'Alembert 78280 Guyancourt, France
[28-3]	16:40-17:00	**[28-3] Visualization of Plasma Currents**
		Byungwhan KIM[*] and Donghwa JUNG *Department of Electronics Engineering, Sejong University, Seoul 143-747, Korea
[28-4]	17:00-17:20	**[28-4] Revisted on RF Compensation in single Probe Measurement**
		ShinJae YOU Korea Research Institute of Standards and Science (KRISS)

Capacitively coupled radio-frequency N_2 discharges at low pressures

L. Marques[1,2,*], L. L. Alves[1], C. D. Pintassilgo[1,3], N. Carrasco[5], L. Boufendi[4] and G. Cernogora[5]

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Capacitively coupled radio-frequency discharges (ccrf) in nitrogen mixtures are frequently used for the processing, modification and functionalization of different kinds of materials. Although nitrogen plasmas have been studied for many years, and despite their growing interest in applications, there is only partial knowledge about ccrf nitrogen plasmas.
This paper uses experiments and modelling to study ccrf discharges in pure nitrogen, at 13.56 MHz frequency, 0.1–1 mbar pressures and 2–30 W coupled powers [1]. Experiments performed on two similar (not twin) setups, existing in the LATMOS and the GREMI laboratories, include electrical and optical emission spectroscopy (OES) measurements. Electrical measurements give the rf-applied and the direct-current-self-bias voltages, the effective power coupled to the plasma and the average electron density. OES diagnostics measure the intensities of radiative transitions with the nitrogen second-positive and first-negative systems, and with the 811.5 nm atomic line of argon (present as an actinometer).
In the particular case of non-equilibrium ccrf discharges in nitrogen, a self-consistent modeling strategy must account for the interplay between the transport of particles, in the presence of density gradients and the rf field, and their production/destruction due to kinetic mechanisms involving both electrons and heavy species. Simulations use a hybrid code that couples a two-dimensional time-dependent fluid module [2], describing the dynamics of the charged particles (electrons and positive ions N_2^+ and N_4^+), and a zero-dimensional kinetic module, describing the production and destruction of nitrogen (atomic and molecular) neutral species [3]. The coupling between these modules adopts the local mean energy approximation to define space–time-dependent electron parameters for the fluid module and to work out space–time-averaged rates for the kinetic module. The model gives general good predictions for the self-bias voltage and for the intensities of radiative transitions (both average and spatially resolved), underestimating the electron density by a factor of 3–4.

REFERENCES:

[1] L. L. Alves, C D Pintassilgo, G Wattieaux, Et Es-sebbar, J Berndt, E Kovacevic, N Carrasco, L Boufendi and G Cernogora, "Capacitively coupled radio-frequency discharges in nitrogen low pressures", *Plasma Sources Sci. Technol.*, vol. 11, pp 045008, 2012.
[2] A. Salabas, G. Gousset and L.L. Alves, "Two-dimensional fluid modelling of charged particle transport in radio-frequency capacitively coupled discharges", *Plasma Sources Sci. Technol.*, vol. 11, pp 448-464, 2002.
[3] V. Guerra, P.A. Sá and J. Loureiro, "Kinetic modeling of low-pressure nitrogen discharges and post-discharges", *Eur. Phys. J.: Appl. Phys.*, vol. 28, pp 125-152, 2004.

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Capacitively coupled radio-frequency N_2 discharges at low pressures

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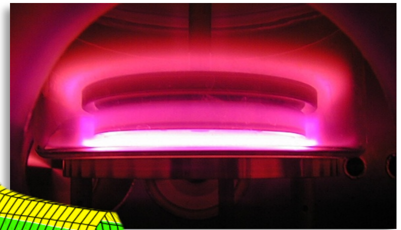

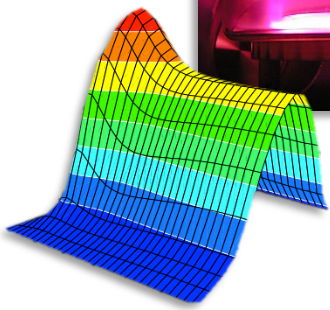

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Outline

- General motivation
- The capacitively coupled radio-frequency (ccrf) reactor
- The 2D, time-dependent fluid model
- Results
- Final remarks