INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Plasmas (LPP)
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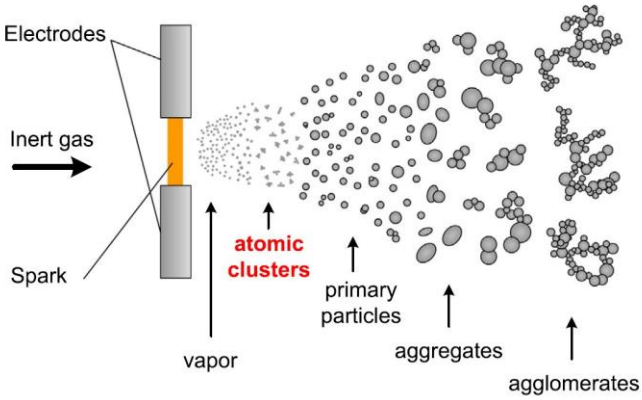
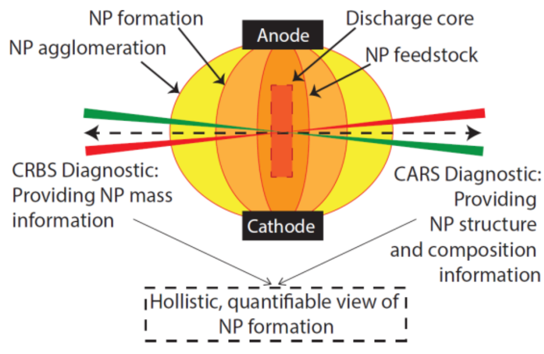
Thesis possibility after internship: YES
Funding: YES Type of funding: ANR PRCI project "NanoByNano"

Nanoparticle synthesis by nanosecond repetitively pulsed plasma discharges



The portable, on-demand, and point-of-use (**POP**) synthesis of nanoparticles (**NP**) can improve the feasibility of mobile applications requiring such materials [1,2]. For example, research in nanoenergetic materials includes using NP in liquid fuels to reduce pollutant emissions such as CO_2 [2]. For electric propulsion in space, NP have been explored as alternative propellants [1]. Conventional techniques for NP synthesis generally operate at local thermodynamic equilibrium (**LTE**) and are not appropriate for POP NP synthesis. However, fast, efficient, finely-controlled synthesis using a simple and compact platform may be possible with nanosecond repetitively pulsed (**NRP**) discharges that initiate non-LTE chemistry to promote nucleation and growth. This project will seek to demonstrate the efficacy NRP discharges for NP synthesis and develop a detailed, quantitative understanding of the synthesis mechanism. These goals will be achieved by linking the properties of the plasma, the products, and the reactive medium through tightly coordinated experiments centered on *in situ* laser diagnostics of spatiotemporal NP growth by using spontaneous Raman spectroscopy [3,4] and coherent anti-Stokes Raman spectroscopy (CARS), as well as optical emission spectroscopy to determine plasma properties. Collaboration with the Luxembourg Institute of Science and Technology on coherent Rayleigh-Brillouin scattering (CRBS) will provide further information on NP properties. Finally, we will develop a detailed, quantitative model of NP growth, which may involve molecular dynamics simulations or theoretical modeling in collaboration with Princeton University (USA).



References:

[1] P. Dietz, W. Gärtner, Q. Koch, P. E. Köhler, Y. Teng, P. R. Schreiner, K. Holste, and P. J. Klar, *Molecular Propellants for Ion Thrusters*, Plasma Sources Science and Technology **28**, 084001 (2019).
[2] R. A. Yetter, *Progress towards Nanoengineered Energetic Materials*, Proceedings of the Combustion Institute **38**, 57 (2021).
[3] D. Z. Pai, *Plasma-Liquid Interfacial Layer Detected by in Situ Raman Light Sheet Microspectroscopy*, Journal of Physics D: Applied Physics **54**, 355201 (2021).

[4] D. Z. Pai, F. Pailloux, and D. Babonneau, *In Situ Raman Spectroscopy of Nanostructuration by Surface Plasmas Generated on Alumina Thin Film-Silicon Bilayers*, Plasma Sources Science and Technology **28**, 085007 (2019).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: NO