

DAVID Z. PAI

CNRS Research Scientist
Laboratoire de Physique des Plasmas
Ecole Polytechnique
Route de Saclay, 91128 Palaiseau, France

Email: david.pai@lpp.polytechnique.fr
Telephone: (+33) 01 69 33 59 60

RESEARCH PROFILE

David Pai specializes in non-equilibrium plasmas at high pressure, the application of such plasmas to nanoscience, and plasma diagnostics. His research work focuses on the experimental and theoretical study of nanosecond repetitively pulsed discharges and their applications in electrohydrodynamics, plasma-surface interaction, and nanomaterials synthesis. His experience with plasma diagnostics includes optical emission spectroscopy, plasma photonic crystals, second-harmonic generation, and in-situ Raman micro-spectroscopy. He has published 30 papers in peer-reviewed journals, 2 patents, and co-authored one book chapter.

EDUCATION

- 2/04 – 1/08 **PhD, Physics, Laboratoire EM2C, Ecole Centrale Paris (Châtenay-Malabry, France)**
Dissertation topic: "Nanosecond repetitively pulsed plasmas in preheated air at atmospheric pressure"
PhD advisors: Christophe O. Laux, Deanna A. Lacoste
- 9/01 – 12/02 **Master of Science, Electrical Engineering, Stanford University (California, USA)**
- 9/97 – 6/01 **Bachelor of Science, Electrical Engineering, Stanford University (California, USA)**

PROFESSIONAL EXPERIENCE

- 1/21 – present **CNRS Research Scientist, Laboratoire de Physique des Plasmas, Ecole Polytechnique (Palaiseau, France)**
Plasma-surface interaction, plasma nanoscience, optical spectroscopy of plasmas
- 6/19 **PHC Orchid project, National Taiwan University of Science and Technology (Taipei, Taiwan)**
Graphene quantum dot synthesis using atmospheric-pressure microplasmas
- 2/19 – 3/19 **Visiting Scholar, King Abdullah University of Science and Technology (Thuwal, Saudi Arabia)**
Electric field induced second harmonic generation
- 12/18 **PHC Orchid project, National Taiwan University of Science and Technology (Taipei, Taiwan)**
Graphene quantum dot synthesis using atmospheric-pressure microplasmas
- 7/18 – 8/18 **Visiting Scholar, Stanford University (California, USA)**
Electron density measurement of plasmas using photonic crystals
- 7/17 – 9/17 **Visiting Scholar, Stanford University**
Electron density measurement of plasmas using photonic crystals
- 1/17 – 2/17 **Visiting Scholar, Stanford University**
Electron density measurement of plasmas using photonic crystals
- 3/16 – 5/16 **Invited Associate Professor, University of Tokyo (Kashiwanoha, Japan)**
Nanostructured surface discharges at high pressure
- 1/15 – 3/15 **Invited Researcher, University of Tokyo**
Surface treatment of transparent conducting oxides using atmospheric microplasma jets
- 10/12 – 2/13 **Invited Researcher, University of Tokyo**
Diamondoid synthesis using plasma microreactors
- 10/12 – 12/20 **CNRS Research Scientist, Institut PPRIME, Université de Poitiers (Chasseneuil Futuroscope, France)**
Plasma-fluid-solid interaction, electrohydrodynamics, microplasmas, plasma nanoscience, optical spectroscopy of plasmas
- 9/10 – 9/12 **JSPS Foreign Post-doctoral Fellow, University of Tokyo**
Raman spectroscopy, plasmas in supercritical fluids, diamondoid synthesis, plasma microreactors
- 8/10 – 9/10 **Visiting Scientist, CSIRO Materials Science and Engineering (Lindfield, Australia)**
Nanomaterials synthesis using nanosecond plasmas
- 2/08 – 8/10 **Post-doctoral scholar, Laboratoire EM2C, Ecole Centrale Paris**
Theoretical study of nanosecond repetitively pulsed discharges
- 2/04 – 1/08 **PhD student, Laboratoire EM2C, Ecole Centrale Paris**
PhD dissertation: *Nanosecond repetitively pulsed discharges generated in preheated air at atmospheric pressure*

SCIENTIFIC PRODUCTION

Publications in peer-reviewed journals:

1. D. Z. Pai (2021). Plasma-liquid interfacial layer detected by in situ Raman light sheet microspectroscopy. *Journal of Physics D: Applied Physics*, 54, 355201.
2. Orrière, T., Kurniawan, D., Chang, Y. C., Pai, D. Z., Chiang, W. H. (2020). Effect of plasma polarity on the synthesis of graphene quantum dots by atmospheric-pressure microplasmas. *Nanotechnology*, 31(48), 485001.
3. Darny, T., Babonneau, D., Camelio, S., & Pai, D. Z. (2020). Uniform propagation of cathode-directed surface ionization waves at atmospheric pressure. *Plasma Sources Science and Technology* 29, 065012.
4. Adamovich, I. V., Butterworth, T., Orriere, T., Pai, D. Z., Lacoste, D. A., & Cha, M. S. (2020). Nanosecond second harmonic generation for electric field measurements with temporal resolution shorter than laser pulse duration. *Journal of Physics D: Applied Physics*, 53(14), 145201.
5. Orrière, T., Moreau, E., & Pai, D. Z. (2019). Electric wind generation by nanosecond repetitively pulsed microplasmas. *Journal of Physics D: Applied Physics*, 52, 464002
6. Yang, J. S., Pai, D. Z., & Chiang, W. H. (2019). Microplasma-enhanced synthesis of colloidal graphene quantum dots at ambient conditions. *Carbon*, 153, 315-319.
7. Pai, D. Z., Pailloux, F., & Babonneau, D. (2019). In situ Raman spectroscopy of nanostructuring by surface plasmas generated on alumina thin film-silicon bilayers. *Plasma Sources Science and Technology*, 28(8), 085007.
8. Pai, D. Z., Righetti, F., Wang, B. C., Biggs, D. R., & Cappelli, M. A. (2019). Electron number density measurements from the frequency shift of a plasma defect state in a one-dimensional photonic crystal. *The European Physical Journal D*, 73(5), 97.
9. Orrière, T., Moreau, E., & Pai, D. Z. (2018). Ionization and recombination in nanosecond repetitively pulsed microplasmas in air at atmospheric pressure. *Journal of Physics D: Applied Physics*, 51(49), 494002.
10. Kawamura, T., Kanno, M., Stauss, S., Kuribara, K., Pai, D. Z., Ito, T., & Terashima, K. (2018). Generation and characterization of field-emitting surface dielectric barrier discharges in liquids. *Journal of Applied Physics*, 123(4), 043301.
11. D. Z. Pai, S. Stauss and K. Terashima, « Field-emitting Townsend regime of surface dielectric barrier discharges emerging at high pressure up to supercritical conditions », *Plasma Sources Science and Technology Vol. 24, No. 2, 025021* (2015)
12. D. Z. Pai, S. Stauss and K. Terashima, « Surface dielectric barrier discharges exhibiting field emission at high pressure », *Plasma Sources Science and Technology Vol. 23, No. 2, 025019* (2014)
13. D. A. Lacoste, H. Muneoka, T. F. Guiberti, D. Z. Pai, K. Urabe, S. Stauss, and K. Terashima, « Effect of light irradiation on Townsend breakdown in helium at 5.2 K », *Plasma Sources Science and Technology Vol. 23, No. 1, 012002* (2014)
14. S. Stauss, C. Ishii, D. Z. Pai, K. Urabe, and K. Terashima, « Diamondoid synthesis in atmospheric pressure adamantane–argon–methane–hydrogen mixtures using a continuous flow plasma microreactor », *Plasma Sources Science and Technology Vol. 23, No. 3, 035016* (2014)
15. S. Stauss, D. Z. Pai, T. Shizuno, and K. Terashima, « Nanosecond Pulsed Electric Discharge Synthesis of Carbon Nanomaterials in Helium at Atmospheric Pressure from Adamantane », *IEEE Transactions on Plasma Science Vol. 42, No. 6, 1594-1601* (2014).
16. D. L. Rusterholtz, D. A. Lacoste, G. D. Stancu, D. Z. Pai, and C. O. Laux, « Ultrafast heating and oxygen dissociation in atmospheric pressure air by nanosecond repetitively pulsed discharges », *Journal of Physics D: Applied Physics Vol. 46, No. 46, 464010* (2013)
17. S. Stauss, H. Muneoka, N. Ebato, F. Oshima, D. Z. Pai, and K. Terashima, « Self-organized pattern formation in helium dielectric barrier discharge cryoplasmas », *Plasma Sources Science and Technology, Vol. 22, No. 2, 025021* (2013)
18. D. Z. Pai, K. Ostrikov, S. Kumar, D. A. Lacoste, I. Levchenko, and C. O. Laux, « Energy efficiency in nanoscale synthesis using nanosecond plasmas », *Scientific reports, Vol. 3, 1221* (2013)
19. F. Oshima, S. Stauss, C. Ishii, D. Z. Pai, and K. Terashima, « Plasma microreactor in supercritical xenon and its application to diamondoid synthesis », *Journal of Physics D: Applied Physics, Vol. 45, No. 40, 402003* (2012)
20. D. A. Lacoste, H. Muneoka, D. Z. Pai, S. Stauss, and K. Terashima, « Breakdown characteristics of a nanosecond-pulsed plasma discharge in supercritical air », *Plasma Sources Science and Technology, Vol. 21, No. 5, 052003* (2012)
21. D. Z. Pai, S. Kumar, I. Levchenko, D. A. Lacoste, C. O. Laux et K. Ostrikov, « Atmospheric-pressure discharges for the fabrication of surface-based metal nanostructures », *IEEE Transactions on Plasma Science, Vol. 39, No. 11, 2814-2815* (2011)
22. S. Stauss, N. Ebato, F. Oshima, H. Muneoka, D. Z. Pai et K. Terashima, « Uniform, filamentary, and striped patterns in helium dielectric barrier discharge cryoplasmas », *IEEE Transactions on Plasma Science, Vol. 39, No. 11, 2184-2185* (2011)
23. F. Tholin, D. L. Rusterholtz, D. A. Lacoste, D. Z. Pai, S. Celestin, J. Jarrige, G. D. Stancu, A. Bourdon et C. O. Laux « Images of a nanosecond repetitively pulsed glow discharge between two point electrodes in air at 300 K and at atmospheric pressure », *IEEE Transactions on Plasma Science Vol. 39, No. 11, 2254-2255* (2011)
24. D. Z. Pai, M. A. Cappelli et C. O. Laux « The structure of nanosecond repetitively pulsed spark discharges in air », *IEEE Transactions on Plasma Science, Vol. 39, No. 11, 2258-2259* (2011)
25. D. Z. Pai « Nanomaterials synthesis at atmospheric pressure using nanosecond discharges », *Journal of Physics D: Applied Physics, Vol. 44, 174024* (2011)
26. D. Z. Pai, D. A. Lacoste et C. O. Laux, « Nanosecond repetitively pulsed discharges in air at atmospheric pressure – the spark regime », *Plasma Sources Science and Technology, Vol. 19, 065015* (2010)
27. D. F. Colas, A. Ferret, D. Z. Pai, D. A. Lacoste et C. O. Laux « Ionic wind generation by a wire-cylinder-plate corona

- discharge in air at atmospheric pressure », *Journal of Applied Physics*, Vol. 108, 103306, (2010)
28. D. Z. Pai, D. A. Lacoste et C. O. Laux « Transitions between corona, glow, and spark regimes of nanosecond repetitively pulsed discharges in air at atmospheric pressure », *Journal of Applied Physics*, Vol. 107, 093303 (2010)
 29. D. Z. Pai, G. D. Stancu, D. A. Lacoste et C. O. Laux « Nanosecond repetitively pulsed discharges in air at atmospheric pressure – the glow regime », *Plasma Sources Science and Technology*, Vol. 18, 045030 (2009)
 30. D. Pai, D. A. Lacoste et C. O. Laux, « Images of Nanosecond Repetitively Pulsed Plasmas in Preheated Air at Atmospheric Pressure », *IEEE Transactions on Plasma Science*, Vol. 36, No. 4, 974-975 (2008)

Book chapters:

1. Z. Machala, D. Z. Pai, M. Janda and C. O. Laux, « Atmospheric Pressure Nanosecond Pulsed Discharge Plasmas », Low Temperature Plasma Technology: Methods and Applications edited by X. P. Lu and P. K. Chu, Boca Raton, CRC Press, Taylor & Francis Group, Chapter 6, pages 119-172 (2013)

Intellectual property:

1. C. O. Laux, J. O. Andreasson, L. C. Raymond, D. Rusterholtz-Duval, D. Pai, D. Lacoste, F. Sainct, S. Mannai, F. Girschig, P. Toniato, E. Pannier, A. Tibère-Inglesse, “Apparatus and methods for generating reactive gas with glow discharges”, U.S. Patent No. 10,283,327. Washington, DC: U.S. Patent and Trademark Office (2019)
2. C. Laux, D. Rusterholtz-Duval, D. Pai, D. Lacoste, F. Sainct, S. Mannai, F. Girschig and P. Toniato « Apparatus for generating reactive gas with glow discharges and methods of use », U.S. Patent No. 9,378,933. Washington, DC: U.S. Patent and Trademark Office (2016)

Invited talks at conferences:

1. D. Z. Pai, “In-situ optical diagnostics of plasma-water interfaces for applications in graphene synthesis”, Materials Research Society Fall 2021 Meeting – Symposium EQ09: Cutting-Edge Plasma Processes for Next-Generation Materials Science Applications, Boston, Massachusetts, 28 November – 3 December 2021
2. D. Z. Pai, “Plasma-water interfaces for applications in nanomaterials synthesis”, 2021 Annual Meeting of the Electrostatics Society of America, Norman, Oklahoma, 14 – 16 June 2021 (*online due to Covid-19*)
3. D. Z. Pai, “In situ Raman spectroscopy at plasma/water interface for nanoparticles synthesis”, European Conference on Plasma Diagnostics, Salamanca, Spain, 7 – 11 June 2021 (*online due to Covid-19*)
4. D. Z. Pai, “In-situ Raman spectroscopy of plasma-activated water for applications in nanomaterials synthesis”, 7th Plasma Science & Entrepreneurship Workshop, Bochum, Germany, 2 – 3 November 2020 (*online due to Covid-19*)
5. D. Z. Pai, et al, “Title to be announced”, 10th International Symposium on Plasma Nanoscience, Cadiz, Spain, 27 September – 1 October, 2020 (*cancelled due to Covid-19*)
6. D. Z. Pai, et al, “Title to be announced”, Semi-Centennial Joint Conference on Electrostatics, Charlottetown, Prince Edward Island, Canada, 7 – 10 June, 2020 (*cancelled due to Covid-19*)
7. D. Z. Pai, T. Orrière, T. Darny, F. Pailloux, D. Babonneau, S. Camelio, W.-H. Chiang, D. Kurniawan, Y.-C. Chang, J.-S. Yang, « In-situ Raman spectroscopy of plasma-surface/liquid interactions at atmospheric pressure”, Gaseous electronic symposia 3, Rogla, Slovenia, 3 – 6 February 2020
8. D. Z. Pai, T. Orrière, T. Darny, F. Pailloux, D. Babonneau, S. Camelio, W.-H. Chiang, D. Kurniawan, Y.-C. Chang, J.-S. Yang, “In-situ Raman spectroscopy of plasma-surface/liquid interactions at atmospheric pressure”, 6th Plasma Science & Entrepreneurship Workshop, Luxembourg, 14 – 15 November 2019
9. D. Z. Pai, T. Darny, F. Pailloux, D. Babonneau, S. Camelio, W.-H. Chiang, J.-S. Yang, “In-situ Raman (& OES) spectroscopy related to nanostructuration by atmospheric-pressure plasmas”, 10th International Symposium on Plasma Nanoscience, Porec, Croatia, 15 – 20 September 2019
10. D. Z. Pai, F. Righetti, B. C. Wang, D. R. Biggs, M. A. Cappelli, “Electron number density measurements from the frequency shift of a plasma defect state in a one-dimensional photonic crystal”, 10th International Workshop on Microplasmas - Satellite Workshop, Kyoto, Japan, 20 – 24 May 2019
11. D. Z. Pai, “Plasma-fluid and plasma-surface interactions of nanosecond pulsed plasmas”, *71st Gaseous Electronics Conference*, Portland, Oregon, USA, 5 – 9 November 2018
12. D. Z. Pai, “In-situ fluid and surface diagnostics of atmospheric-pressure microplasmas”, *5th International Workshop on Plasma Surface Interactions: Plasma Science & Entrepreneurship 2018*, St. Gallen, Switzerland, 18 - 19 October 2018
13. D. Z. Pai, “Plasma-fluid-surface diagnostics of nanosecond pulsed plasmas”, *9th International Symposium on Plasma Nanoscience*, New Buffalo, Michigan, USA, 26 - 29 August 2018
14. D. Z. Pai, T. Orrière, T. Darny, N. Benard, E. Moreau, D. Babonneau, S. Camelio, « Nanosecond repetitively pulsed microplasmas generated at atmospheric pressure: surface and fluid interactions, and perspectives on applications », *4th International Workshop on Plasma Surface Interactions: Plasma Science & Entrepreneurship 2017*, Orléans, 30 November – 1 December 2017
15. D. Z. Pai, T. Orrière, T. Darny, N. Benard, E. Moreau, D. Babonneau, S. Camelio, « Nanosecond repetitively pulsed microplasmas and perspectives on the synthesis of carbon nanomaterials », *9th International Conference on Functional Carbons*, Taipei, Taiwan, 1-4 November 2017
16. D. Z. Pai, « Plasma-fluid-surface interaction of atmospheric microplasmas », *9th International Workshop on Microplasmas*, Garmisch-Partenkirchen, Germany, 6-9 June 2017

17. D. Z. Pai, « Potential role of electrohydrodynamics in nanomaterials synthesis », *7th International Symposium on Plasma Nanoscience*, Vravrona, Greece, 16 - 20 October 2016
18. D. Z. Pai, « Décharges nanosecondes répétitives pulsées (NRP): physique et applications », *Journées du Réseau Plasmas Froids*, La Rochelle, 14 – 17 October 2013
19. D. Z. Pai, S. Stauss, C. Ishii, K. Terashima, « Atmospheric-pressure plasma microreactors for diamondoid synthesis », *4th International Symposium on Plasma Nanoscience*, Monterey, California, 25 -29 August 2013
20. D. Z. Pai, S. Stauss, K. Terashima, « In-situ monitoring of plasma chemistry during diamondoid synthesis using plasma discharges », *3rd International Symposium on Plasma Nanoscience*, Johor, Malaysia, 26 February – 1 March 2012
21. D. Z. Pai, D. A. Lacoste, C. O. Laux, K. Ostrikov, S. Kumar et I. Levchenko, « Nanomaterials synthesis using nanosecond discharges in air at atmospheric pressure », *2nd International Symposium on Plasma Nanoscience*, Murrumbidgee, Australia, 12-15 December 2010

Seminars and courses:

1. « In-situ Raman spectroscopy of bulk liquid versus interfaces of water in contact with atmospheric pressure plasmas », *tutorial/ review for International Online Plasma Seminar*, 25 November 2021
2. « Plasma-water interfaces for graphene quantum dot (GQD) synthesis in aqueous solution », *invited seminar at Laboratoire de Physique des Interfaces et des Couches Minces*, Palaiseau, France, 7 April 2021
3. « Introduction à la physique des décharges impulsives (Partie 1) », *course at Ecole Technologique des Plasmas Froids 15^{ème} Journées du Réseau*, Saint-Dié-des-Vosges, France, 29 September, 2020
4. « Interaction plasma-fluide-surface des plasmas froids », *invited seminar at Laboratoire de Génie Electrique de Grenoble (G2Elab)*, Grenoble, France, 25 November 2016
5. « Plasma-fluid-surface interaction of low-temperature plasmas at atmospheric pressure and above », *invited seminar at the University of Tokyo*, Kashiwanoha, Japan, 28 April 2016
6. « Physics of interfaces with atmospheric cold plasmas », *seminar at Saint Gobain Recherche*, Paris, France, 14 November 2013
7. « Décharges nanosecondes répétitives pulsées (NRP) : physique et applications », *course at 11^{ème} Journées d'Echange du Réseau des Technologies des Plasmas Froids*, La Rochelle, France, 14 October, 2013
8. « UC Berkeley Seminar », *seminar at the University of California at Berkeley*, Berkeley, California, USA, 19 August 2013

RESEARCH SUPPORT

External grants awarded:

- “Synthesis of metal-graphene nanocomposites by microplasma”, CNRS International Emerging Actions, Principal Investigator, 14000 €, 2 years, 13/2/2020 – 31/12/2021
- “PLASMAFACE: Plasma-fluid-surface interaction at interfaces of low-temperature atmospheric-pressure plasmas,” ANR Young Researcher Grant, Principal Investigator, 275000 €, 5 years, 1/10/2015 – 30/9/2020
- “In-situ spectroscopic study of nanomaterials synthesis by microplasma-assisted electrochemistry,” PHC Orchid Project, French Principal Investigator, 9600 €, 2 years, 1/1/2018 – 31/12/2019
- “Electron density measurement of surface dielectric barrier discharges using photonic crystals,” Stanford-France Collaborative Project, French Principal Investigator, \$15000, 2 years, 1/9/2016 – 31/8/2018

Internal grants awarded:

- “Study of nanostructured surface discharges,” COS Pprime Grant, Principal Investigator, 4000 €, 1 year, 1/10/2013 – 30/09/2014

TEACHING AND ADVISING

Teaching:

- Teaching assistant for course in physics for first-year engineering students (Stanford University)
- Section leader for course in quantum and statistical physics (Ecole Centrale Paris)
- Teaching assistant for laboratory course in optical spectroscopy (Ecole Centrale Paris)
- Instructor for laboratory course in chemical engineering (University of Poitiers, 2016 – 2018)

Supervision:

- Supervisor for 8 internships by undergraduate and 1st Year Master’s students
- Supervisor or co-supervisor for 3 internships by 2nd Year Master students
- Supervision of PhD students:
 - Thomas Orrière, University of Poitiers, 9/2014 – 5/2018, graduated 6 June 2018
 - Darwin Kurniawan, National Taiwan University of Science and Technology, 9/2019 – 12/2019
- Supervision of postdoctoral scholars:
 - Hitoshi Muneoka, University of Tokyo, 1/2016 – 2/2016
 - Thibault Darny, University of Poitiers, 4/2017 – 3/2019
 - Thomas Orrière, King Abdullah University of Science and Technology, 2/2019 – 1/2020

- Thomas Orrière, University of Poitiers, 2/2020 – 1/2021

ACADEMIC SERVICE

- Steering committee, Réseau des Plasmas Froids, 2021 – 2026
- Local organizing committee, Journées GDR EMILI, 2021
- International committee, 48th EPS Conference 2021 on Plasma Physics, Greece
- National organizing committee for “Rencontres scientifiques plasmas froids et lasers”, Toulouse, France, 25 – 27 November 2019
- Member of local organizing committee for the 10th Conference of the French Electrostatics Society (August 29 – 31, 2016)
- Provided assistance to the international scientific evaluation of the CNRS (2016)
- Member of 4 PhD dissertation committees: Ecole Centrale Paris (2013, 2020), Université de Toulouse (2016), Ecole Polytechnique (May 2021)
- Elected member of departmental council, Institut Pprime 2018 – 2022
- Seminar coordinator for the Department of Fluids, Combustion, and Thermal Science at the Institut Pprime
- Referee for grant proposals submitted to the National Science Foundation (USA) and the Czech Science Foundation (Czech Republic)
- Referee for grant pre-proposals submitted to the French National Research Agency
- Referee for peer review for the journals: *Applied Physics Letters*, *Japanese Journal of Applied Physics*, *Journal of Alloys and Compounds*, *IEEE Trans. in Plasma Science*, *Journal of Physics D*, *Thin Solid Films*, *Plasma Sources Sci. & Tech.*, *European Physical Lett.*, *Measurement Sci. & Tech.*, *European Physical Journal D*, *European Physical Journal – Applied Physics*, *Physics Letters A*, *Plasma Chemistry & Plasma Processing*, *Spectrochimica Acta Part A*, *High Voltage Engineering*, *Journal of Vacuum Science and Technology A*