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Particle modeling of ionic liquid permeation, emission and plume neutralization in electrospray propulsion system

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Electrospray propulsion systems are most suitable for micro-nano satellites in advantage of small size, low power consumption and high specific impulse. For electrospray thrusters, ionic liquid is the preferred propellant because of its low volatility, high electrical conductivity and thermal stability [1]. Recently, J. MacArthur et al. reported a novel microfluidic valve using the electric field force as the driving force to controls the supply of ionic liquid propellant to the electrospray thruster [2]. The ionic liquid propellant is induced to produce charged ions or droplets which are then accelerated by the applied electric field to generate thrust. The ionic liquid permeation controlled by an electroweting valve, emission and plume neutralization in electrospray propulsion system is essentially the interaction of ion-ion plasma, but little is known about the underlying mechanisms.

Therefore, we utilizes a molecular dynamics model and a particle-in-cell model to investigate the physics of ionic liquid permeation, electrospray emission and plume neutralization respectively. Several interesting findings are observed. Our studies shows that the permeation process of ionic liquid nanodroplet on a silicon substrate driven by electrowetting is dominated by the combination of the interaction between the ionic liquid and the substrate and the effect of applied electric field [3]. Furthermore, compared with conventional capillary emitter, ions are more easily emitted from the hybrid emitter, which transits from the externally-wetted emission mode into the capillary emission mode with the increasing propellant flow rate [4]. Last but not least important, the plume neutralization of the ionic liquid electrospray thruster is achieved by the spatial and temporal oscillations of the ion beams [5]. These findings will provide significant references for the optimal design and reliable operation of electrospray propulsion system.

References

[1] Fernández de la Mora J, Annu. Rev. Fluid Mech. **39**, 217–243 (2007).
[2] J. MacArthur, B. O. Kristinsson, D. Freeman, *et al*, 36th International Electric Propulsion Conference, Vienna, Asturia, 2019, IEPC-2019-909.
[3] J. R. Zhang, K. Zhang, W. Z. Wang, *et al*, J. Colloid Interface Sci. **608**, 114–119 (2022).
[4] J. R. Zhang, G. B. Cai, A. Shahzad, *et al*, Int. J. Heat Mass Transf. **175,** 121369 (2021).
[5] B. Y. Zhang, G. B. Cai, B. J. He, *et al*, Plasma Sources Sci. Technol. **30**, 125009 (2021).

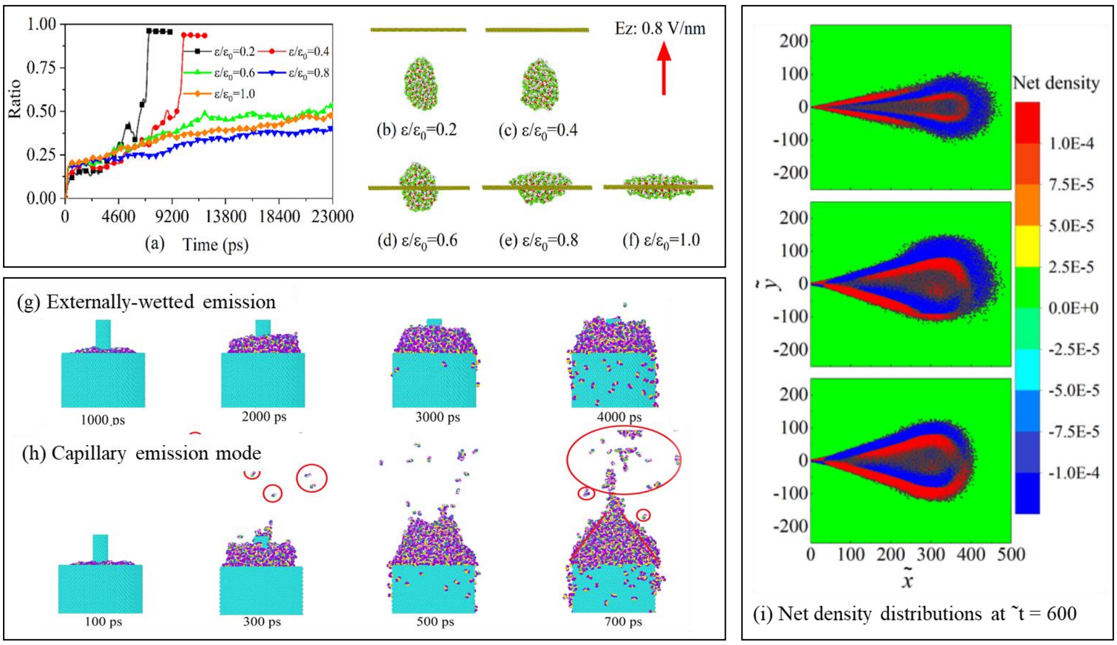

Figure 1. (a) Permeation on substrate with varying wettability, (b) (c) (d) (e) (f) Snapshot of final state of simulation [3]; (g), (h) Different operating modes for the hybrid emitter case [4]; (i) plasma oscillations of the ion beams during the plume neutralization process[5].