Electrostatic Energy Harvesting with Nanoscale Jumping Droplets

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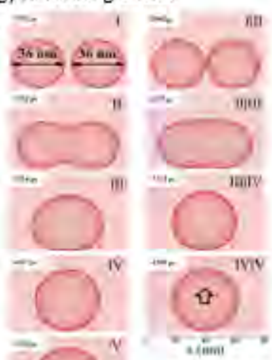
Abstract

- Harvesting of energy in a nanoscale environment through the usage of the jumping droplet phenomenon.
- Jumping droplets have been found to be positively charged.
- Opportunity to harvest that energy due to potential energy difference.

Figure 1: Energy Harvesting Device

- Power density in the jumping droplet energy-harvesting device is proportional to square of jumping velocity.
- Results of this project would be useful in enhancing the energy conversion efficiency.



Liang et al., Appl. Phys. Lett. 107, 143105 (2015)

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Applications

1. Heat pipes and thermal diodes

Rectification coefficient (diodicity):

$$\eta = \frac{k_f - k_r}{k_r} > 100.$$

2. Self-cleaning surface

Removal of contaminating particles without external forces.

Boreyko et al., Appl. Phys. Lett. 99, 234105 (2011).

Wisdom et al., PNAS 110, 7992 (2013).

Simulation Setup

- Through the use of MD Simulation coding software and visualization tools:
- Achieve thermal equilibrium over multiple temperatures 50K to 95K. To determine liquid phase change point.

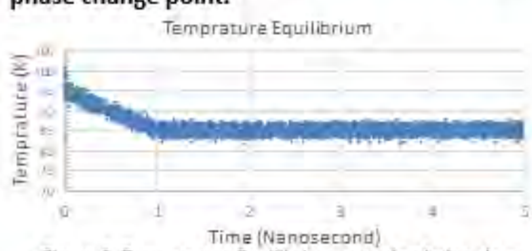

Figure 2: Temperature Equilibrium over simulation time.

- Achieve phase change and reduce temperature to published data temperature.
- Expand space to simulate droplet.
- Determine thermodynamic properties of droplet at thermal equilibrium.

Results

- Argon droplet was successfully simulated:

$$R_{Droplet} = 3.9\ \mathrm{nm}$$

- Surface tension curtesy of Tyler Hinton:

$$\gamma_{Surface\ Tension} = 0.008\frac{\mathrm{N}}{\mathrm{m}}$$

- Pressure of system:

$$P_{Vapor} = 3.22\ \mathrm{atm}$$

$$P_{Inside\ Droplet} = 44.389\ \mathrm{atm}$$

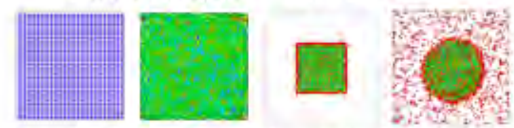

Figure 3: Forming of droplet through visualization tool.

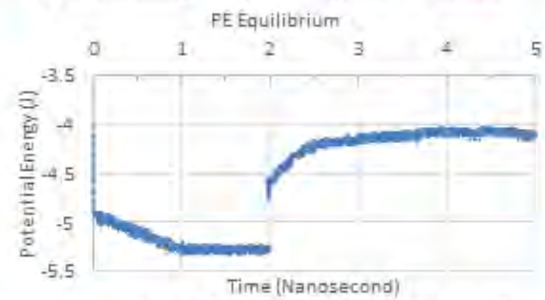

Figure 4: Equilibrium of Potential Energy over time

Conclusion and Future Work

- Results agree with existing research.
- Future simulations to include multiple droplets.
- Merging droplets to study velocity dependence on radius.
- Charging droplets for purposes of energy harvesting.

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