

DBD Plasma Actuators: A Compact, Near-Silent Alternative for Electronics Cooling

Operating Principle

Physics of DBD Plasma:

1. Two asymmetrical electrodes (one exposed, one buried) separated by a dielectric layer.
2. High-voltage AC discharge ionizes nearby air, generating a **thin plasma region**.
3. The resulting **ionized airflow**—the “ionic wind”—enhances convective heat transfer on surfaces.

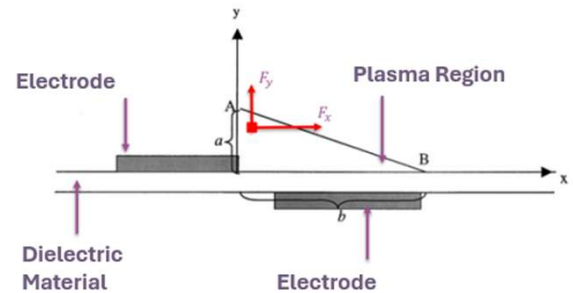
Advantages

- **No Moving Parts:** Nearly silent operation (< 12 dBA in some tests)
- **Ultra-Thin Form Factor:** Typically, a few mm thick

DBD Actuator Model Integration

In this approach, the DBD actuator model is coupled with the Navier–Stokes equations and the energy equation to accurately capture both flow dynamics and heat transfer. The electric field ionizes the fluid in the plasma region, creating a volumetric force that modifies the local velocity and pressure distribution. This alteration of the boundary layer enhances convection, leading to improved heat dissipation in electronic systems.

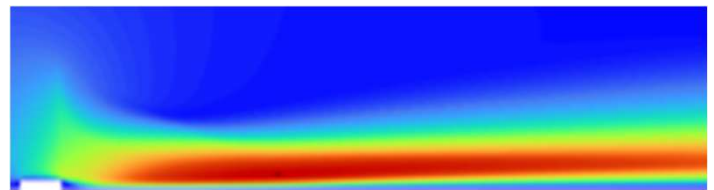
By including the electrohydrodynamic (EHD) force in the governing equations, we can predict and optimize the overall thermal performance of the system.



$$\partial_t \mathbf{A} + \partial_x \mathbf{B} + \partial_y \mathbf{C} = \mathbf{D} \quad (9)$$

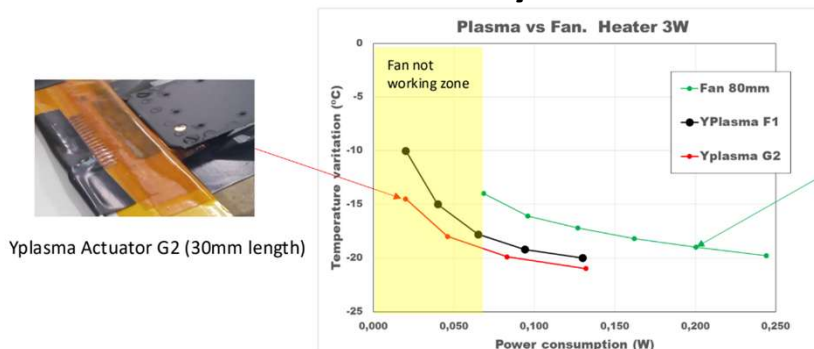
where

$$\mathbf{A} = \begin{bmatrix} 0 \\ \rho u \\ \rho v \\ \rho e \end{bmatrix}, \mathbf{B} = \begin{bmatrix} u \\ \rho u^2 + p - \tau_{xx} \\ \rho uv - \tau_{yx} \\ \rho ue - u\tau_{xx} - v\tau_{xy} - \kappa\partial_x T \end{bmatrix}, \mathbf{C} = \begin{bmatrix} v \\ \rho uv - \tau_{xy} \\ \rho v^2 + p - \tau_{yy} \\ \rho ve - u\tau_{yx} - v\tau_{yy} - \kappa\partial_y T \end{bmatrix}, \mathbf{D} = \begin{bmatrix} 0 \\ F_{effx} \\ F_{effy} \\ 0 \end{bmatrix} \quad (10)$$



Velocity magnitude generated by the actuator without incoming flow. The applied voltage and frequency are 4 kV and 3 kHz.

Key Results



Applications and Use Cases

Consumer Electronics

Laptops, tablets, smartphones – ideal for ultra-thin designs and reduced noise.

Servers & Data Centers

Targeted cooling for high-density racks, potentially reducing fan noise.

High-Power LED Lighting

Substitutes small, noisy fans in compact luminaires.

Industrial Equipment

Control panels and automation systems in dusty or noise-sensitive environments.