Particles in Microdischarge Plasma: Coulombic Interactions and Optical Effects

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Objective

Coulombic interactions of micron~sized particles were studied inside a microplasma. Studying the formation of Coulomb crystals and particle interactions may help characterize the microplasma and help improve device performance.

Background – Microdischarge Devices

High electric fields, driven by AC or DC source, generate localized microplasma. The latest design of microdischarge devices utilizes the dielectric property of alumina (Al_2O_3).

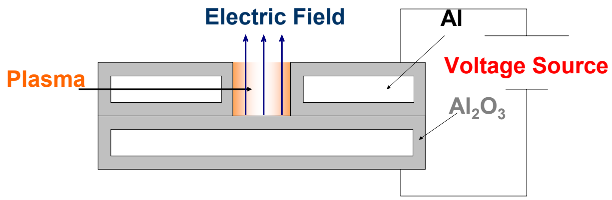
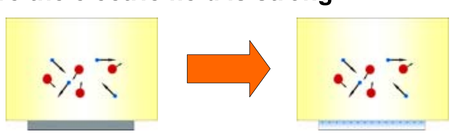


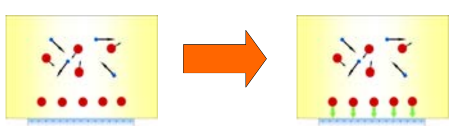
Figure 1. Microdischarge Device with Alumina Layers

Background – Dusty Plasma Physics

Particles in plasma can form a stabilized configuration known as a Coulomb crystal. Most formation occurs near plasma-sheath boundary, where the electric field is strong.



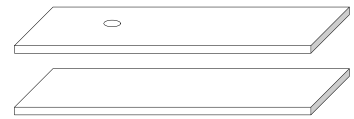
1. Ions and Electrons – Negatively Charged Surface



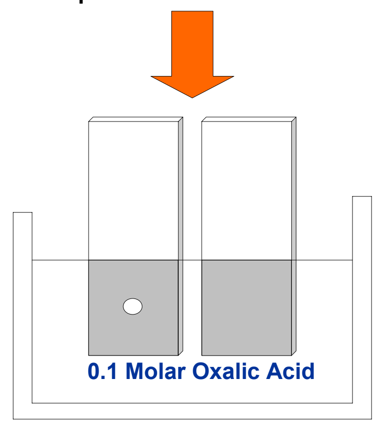
2. Ions and Surface – Strong Electric Field

Figure 2. Formation of Plasma-Sheath Boundary

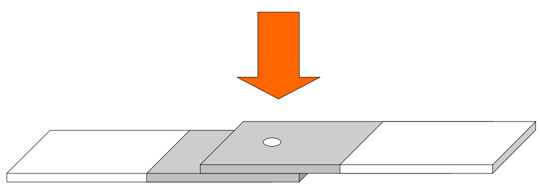
Fabrication



1. Two Aluminum Substrates:
   Top substrate mechanically drilled to diameter of 100 ~ 200 μm



2. Anodization:
   The time length of anodization controls the thickness of Al_2O_3 layer. Thickness > 10 μm



3. Bonding:
   Top and bottom substrates are bonded using Al_2O_3 paste and baked in a high temperature oven

Figure 3. Device Fabrication Process

Experiment

Particles Placed in Microcavities:

- Ho:YLF Crystals
- Green Phosphor
- Ferromagnetic Microspheres

Gases Filled in Vacuum Chamber

- Ne_2
- He_2
- Ar_2-N_2

Figure 4. Vacuum Chamber

Results

- Ho:YLF Crystals: Low emission
  No discernable movement
- Green Phosphor: Clear emission
  Distinct particle movement
  but no stable configuration
- Ferromagnetic Microspheres:
  Bright white light emission
  Unable to track movement

Acknowledgments

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