Dependence of ozone generation on the surface condition of dielectrics

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Introduction

Ozone
High reactivity: O₂, NO, Br₂, CH₄, SO₂, H₂S
Environmentally intensive activities

- Ozone generation from O₂ using Dielectric Barrier discharge
  - Proposed by Hartman (1977)
  - Presence of a dielectric layer between the discharge gap and at least one of the electrodes.

Advantages
- Efficient generation of ozone
- Efficient generation of energetic electrons to make radicals
- Electron traps are the source of ozone
- A device of simple structure

Discharge conditions
- Nanosecond discharge
- To generate high density ozone efficiently
- Higher ozone generation from Atmospheric O₃ even UVB had been decayed

Governing equations

- Coupled reaction
  \( \frac{dx_i}{dt} = -x_i \sum_{j=1}^{n} \frac{k_{ij}}{k_{ji}} \)
- Electron energy conservation
  \( \frac{dE}{dt} = -\sum_{i=1}^{n} E_i \left( \frac{dx_i}{dt} \right) \)
- Photons equation
  \( \frac{dP}{dt} = \sum_{i=1}^{n} \frac{dP_i}{dt} = \sum_{i=1}^{n} \left( \frac{dx_i}{dt} \right) \)

Objective

To show the mechanism of this phenomenon.

Dependence of ozone generation on secondary electron emission coefficient is examined.

Modeling

Boundary Condition
- Gas & pressure: O₂(100%), N₂/Ar
- Dielectric Barrier thickness: 4-8 mm
- V₀: 4.7 kV
- Gap length: 9.3 mm
- Applied voltage: 20±2 kV
- Frequency: 2 MHz
- Initial gas temperature: 300 K
- Secondary Electron Emission Coefficient (S.E.E.C.): 1.5 x 10⁻² eV⁻¹, 0.5 x 10⁻² eV⁻¹
- Gas density: 1 x 10⁻⁵ m⁻³, 5 x 10⁻⁵ m⁻³

Reaction equations

- Reaction Term 1st
  \( \text{Reaction Term 1st} = k_1 \cdot [A] \cdot [B] \)
- Reaction Term 2nd
  \( \text{Reaction Term 2nd} = k_2 \cdot [C] \cdot [D] \)

Conclusion

- To examine the dependence of ozone generation on S.E.E.C., the modeling of AC atmospheric Ozone in ozone has been made.
- The current density wave contains large current peaks of the early period of discharge and small peaks following them.
- Electron density waves: don't synchronize with current density waves.
- High ozone density regions: not high, too, small current discharges are present there.
- Atomic ozone is generated by dissociation reaction.
- High ozone density regions are corresponding to the region where atomic oxygen density are high.
- As \( n \) increases, higher and higher densities are obtained.
- In high S.E.E.C., current density increases.
- In low S.E.E.C., current density decreases.

Electron density

Spatial distributions of electron density averaged by one cycle.

Gas Temperature

Spatial distributions of gas temperature averaged by one cycle.

O₂/P density

Spatial distributions of O₂/P density averaged by one cycle.