Actuator Development Theme

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State-of-the-Art

• **Strengths**
  - Easy to vary current design to explore space
  - Addition of elements, electrodes, multiple dielectrics, arrays, unsteady input, etc. to increase performance
  - Current design works very well in thin b.l.

• **Weaknesses**
  - Limit of current control authority (hence, penetration) – this is the biggest limitation of current designs
  - Understanding of important factors in actuator design and optimization
  - Current design works very well in only thin b.l. (blessing and curse of DBDs)
  - Size of design space
Issues

• 2 separate issues
  – How to improve DBD output/control authority (development)
  – Where and how to use them

• Define the correct metrics for each application

• Figures of merit
  – Brute force thrust (more is always better)
  – Thrust/power (power efficiency)
  – Thrust/full system weight (T/W)
  – Plasma thickness or volume (higher mass flow rate and less impact of viscous effects)
  – Plasma induced velocity (tangential jet)
  – Standardize measurements of parameters, such as thrust, including a standard set of benchmark experiments (both quiescent and FC)
Things We Need to Advance State-of-Art 1

• What are the dominant mechanisms in DBD (species, charge density, mixing, etc.) and how can we exploit them?

• How does the flow affect the plasma and how does the plasma affect the flow?
  – *Standard procedures for measuring actuator performance.*

• Need to move away from acrylic and copper tape actuators

• Better diagnostics to measure plasma at surface to understand the processes
  – *Spectroscopy, electric fields, charge density*

• Dynamics of nano-second pulses
Things We Need to Advance State-of-Art 2

• Increasing volume of plasma (mdot) – both thickness and length

• Micro-actuators, distributed arrays

• Penetration effects
  – Getting plasma away from surface
  – Getting plasma induced jet away from surface

• Materials, coatings

• Tailored and dynamically controlled dielectrics and better understanding the impact of surface charge
  – To modelers, don’t constrain on fixed dielectric constant
  – Multi-functional materials and designs

• Micro-structure of electrodes
Things We Need to Advance State-of-Art 3

• Avoiding thrust cancellation between forward and reverse portions of cycle
• Discharge uniformity
• Robustness and fault tolerance
  – Again, materials – move away from exposed organic dielectrics
• Increasing field strength in sheath, ion density
  – Plasma catalysis – films and coatings on dielectrics
  – Introducing ions upstream w/o lowering air breakdown threshold
• Inverse design method
  – Placement of fields and properties to produce required output
• Power supply, conditioning, impedance matching, etc.
Random Thoughts

• Think like an electron (but be positive)
• What have we done that hasn’t already been done before (flight Russians, ca. 1970)
• Modeling must determine what is exploitable than we can design actuators around that
• Do small advancements translate to better control authority at different scales for different actuators? (How do changes in actuator parameters scale?)