A quartz dielectric tube provides gas confinement in the helicon discharge of the VASIMR (Variable Specific Impulse Magnetoplasma Rocket) VX-50 experiment. Despite highly aligned magnetic field lines to confine the plasma in the discharge, significant thermal heating of the dielectric tube occurs. We perform infrared camera imaging studies of heating of the tube with varying operational parameters of the experiment. Results show decreased heating of the tube as the plasma becomes more highly magnetized and less collisional. The data follows a trend that is well represented by a Bohm transport of ions perpendicular to the magnetic field lines suggesting that ion impact on the tube rather than radiation is the primary heating mechanism. Highly localized heating is also observed directly under the antenna in regions where the coils lie closest to the tube surface. This phenomenon is attributed to capacitive coupling effects that accelerate ions under the antenna coils, increasing the local energy flux to the tube surface.

**EXPERIMENTAL SETUP**

**RESULTS**

**Magnetic Field Strength**

- Stronger B-field provides more magnetized plasma and less wall heating.
- **B = 0.12T**
- **B = 0.23T**
- **B = 0.38T**

**Argon vs. Neon**

- The lighter gas (Neon) is more magnetized and shows less heating. 25% of RF power goes into the quartz vs. 29% for Argon.

**Neutral Flow Rate**

- Higher neutral inflow increases collision rates, thus increasing diffusion.

**Anomalous (Bohm) Diffusion**

- The IR camera captures wall heating rates which are due to heating from particle bombardment (both perpendicular and parallel to B) and radiation. Heating rates scale with a trend similar to Bohm diffusion of particles and not radiation.

**Capacitive Coupling**

- Highly localized heating under upper portion of antenna
- Antenna closer to tube surface here
- More efficient capacitive coupling
- Ions accelerate towards antenna into wall

**Varying Source Conditions**

- As operational parameters change, RF coupling and therefore plasma conditions can change, notably ion density in the source from which particles are diffusing. An example is increasing ion density with B-field, shown below. Ne data under the antenna is not available, but both downstream density (below) and upstream neutral P increase with B, indicating likely source density increases. Despite this, tube heating decreases with B.

**Energy Loss Dominated by Particle Diffusion**

**Heat Flux from IR Data**

- Based on the delta T between the images, calculate the heat flux required at each pixel to produce the necessary temperature rise.
  - Assumes k, C are functions of T
  - Axial, azimuthal conduction small on out time scale
  - Diffuse, gray surface radiating
  - T under portion hidden by antenna equal to T seen at antenna edge
  - \( q = mC \frac{dT}{dt} \)
- A finite difference algorithm was also used to simulate the temperature evolution using 3D transient conduction with an R-C thermal model. Results from this model validate assumptions for simple model used above.