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Triple Points Enhance Thermally-Driven Plasma Generation Using Pyroelectric Crystals

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INTRODUCTION

- Plasma are ionized gases with a wide range of medical, industrial, electrical uses.
- Traditional methods of generating non-equilibrium gas discharges require using electrodes at thousands of volts,
- Pyroelectric crystals offer the potential to generate a plasma using an **alternative sources of energy** such as heat[1].

GOALS OF THIS STUDY

The **specific goals** of this study are to:

- Develop a thermally-driven testing rig that can accommodate varying crystal type, thermal cycle, etc.
- Discover strategies to enhance the plasma current to an extent suitable for practical use

EXPERIMENTAL SETUP

Figure 1 shows the experimental set-up. The variables tested were

- Heating rate
- Heating period
- Pyroelectric crystal material
- Distance to plate
- Crystal surface modification (electrodes, silver paint, etc.)

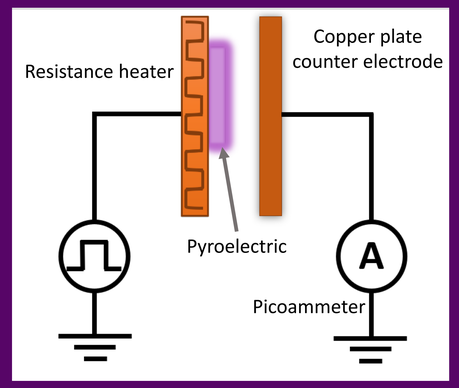

Figure 1. Experimental setup of thermally-driven plasma generation testing rig

RESULTS AND CONCLUSIONS

The intersections between a metal, gas, and dielectric (in this case, a pyroelectric crystal), has been known to substantially enhance the electric field, a prerequisite for atmospheric plasma generation[2].

This "triple point" was created on the surface of a $LiTaO_3$ crystal by coating areas of the surface with silver paint. A 30 s exposure photo of the plasma is shown in Figure 2. By modifying the surface, the measured current of the generated plasma increased almost tenfold, as shown in Figure 3.

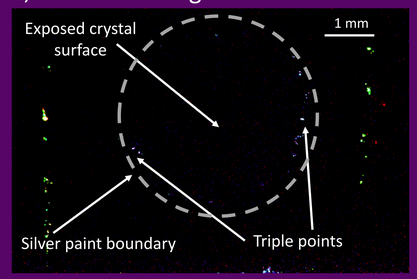

Figure 2. 30 s exposure imaging of plasma generation from modified pyroelectric crystal

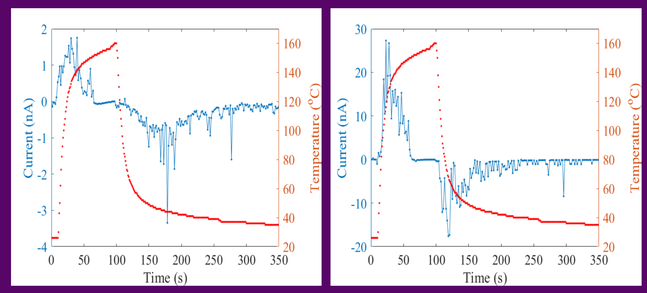

Figure 3. Plots of current and temperature vs. time for plain (left) and painted (right) 1x1 cm $LiTaO_3$ crystal subject to 1.25 W/cm^2 heat flux.

The **current** of the thermally-driven plasma was **successfully enhanced** by modifying the surface of the pyroelectric with artificial **triple points**.

Future Work

- Determine optimal configuration of surface modification to achieve maximum plasma current
- Determine optimal crystal type for most efficient thermal-to-plasma conversion
- Develop apparatus to naturally cycle heat

References:
[1]Johnson et al., 2014, *Plasma Sources Science and Technology,* 23:065018
[2]KJordan et al., 2007, *Journal of Applied Physics,* 102:033301

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