A Gallium-Based Ignitron

for High-Current Pulsed Power Applications

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Purpose of Project

Standard traditional ignitrons are built with mercury as the liquid metal of choice. The purpose of this project is to design and build a gallium-based ignitron to mitigate any potential hazards and environmental impacts associated with mercury-based ignitrons currently used.

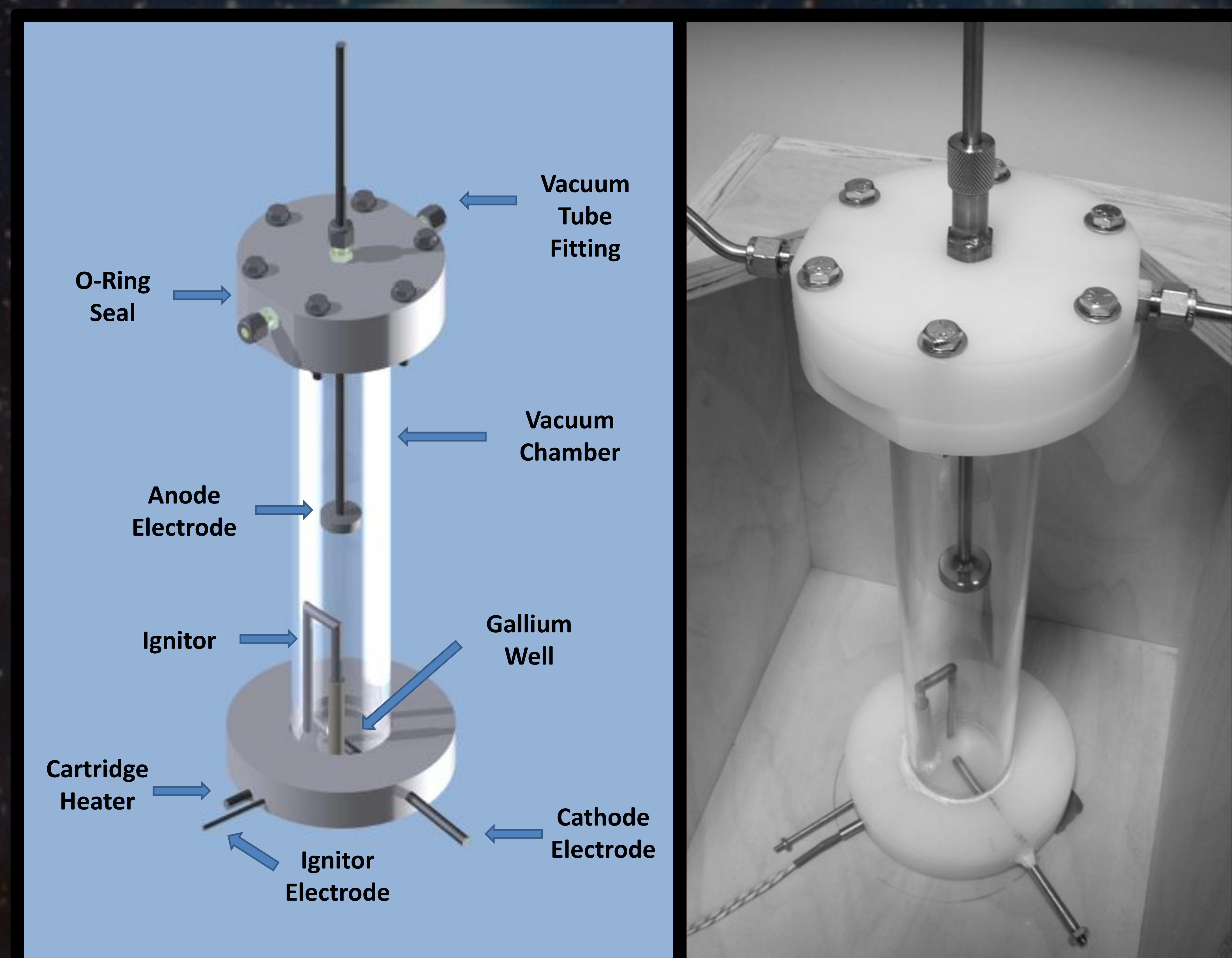
Our goal is to demonstrate that this alternative metal will provide for high-current switching without compromising any of the beneficial operational aspects of an ignitron over time.

Uses and Benefits

An ignitron is a type of switching device used in high-current pulsed power applications. Ignitrons can switch hundreds of kA and hold off tens of kV between pulses. Example applications include: high-power rectification, pulsed magnetically-compressed fusion, and pulsed plasma thrusters.

Two benefits associated with ignitrons include a fast current rise time while also having an inherent turn off mechanism when the power is no longer sufficient to resupply metallic atoms to the arc, and higher current ratings (15kA) that result from increased contact area and lessened resistance created by the plasma arc.

Design Specifications

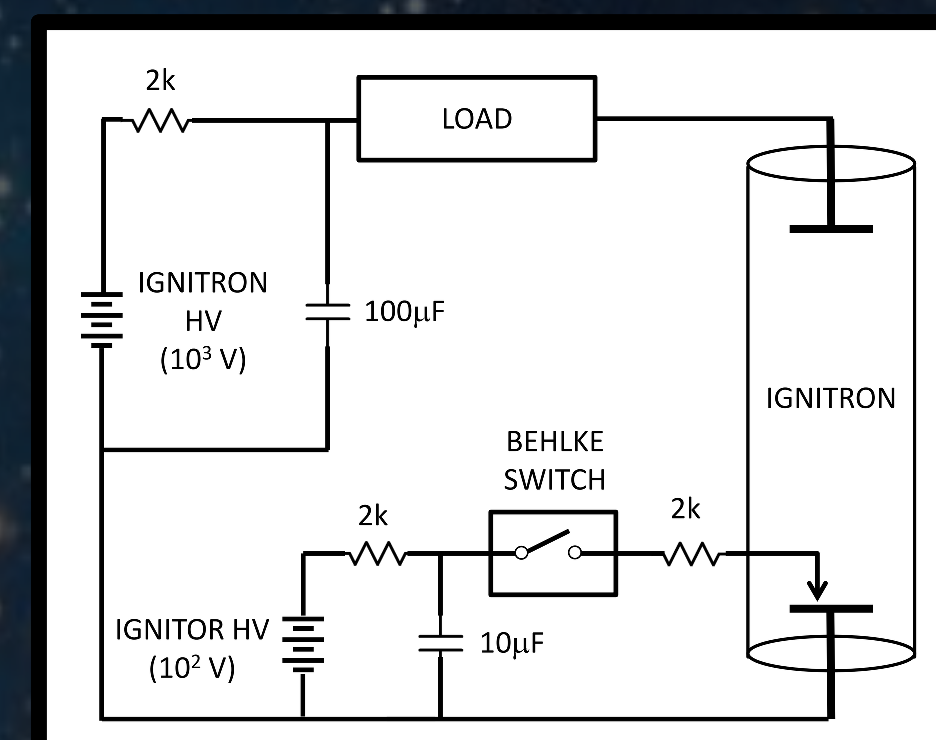


The materials used to construct this ignitron were chosen based on availability, cost, conductive/insulating properties, and compatibility with gallium. The glass tube that serves as the vacuum chamber is an important feature of this design because it allows us to visually inspect the quantity and location of gallium that redeposits on the chamber walls. Our biggest concern with this design is gallium's plating ability, which could create a short between the two electrodes. The optical transparency of the glass along with its insulating properties make it an ideal material for testing this.

How Ignitrons Work

Ignitrons create a short-lived electrical connection between two electrodes via a plasma arc that is continually resupplied from a pool of liquid metal. The plasma arc is created in the vacuum chamber by sending a current pulse from an ignitor through the pool of liquid metal to cause an initial vaporization of metal through ohmic heating.

In pulsed power systems, power supplies charge capacitors over a long period of time at low average power. The high-current switch allows for a fast discharge of the capacitors, providing very high instantaneous power (MW-GW) over a very short timescale (ms).



Future Work

Once apparatus construction is complete the testing and modification phase will commence. During this phase we will study how electrode geometry, electrode spacing, electrode composition, ignition pulse duration, voltage, capacitance, and vacuum pressure impact switch lifetime, erosion, and performance. Using that data we will compare performance to that of mercury-based ignitrons.

References: Burke, J. E. (1989, August). Plasma diagnostics on high current ignitrons.
Eckhardt et al. (1990). *U.S. Patent No. 4970440*. Washington, DC: U.S. Patent and Trademark Office
Acknowledgements: J. B. Pearson, M. Chavers, T. Reid, R. Sullenberger, L. Walker, A. Hallock, K. Bonds