Project 2

- **Title: Waste-to-Energy and Water Treatment: Scaling Up to Industrial Size Gliding Arc Plasma**
- **PI:** Alexander Rabinovich, Drexel University
- **Need and Relevance:** waste-to-energy and water treatment processes require large scale gliding arc plasma systems
- **Goals:** to identify parameters of single base plasma unit and the optimal scheme of combining it to industrial size up to 300kW. **Approach:** measurements of V-I characteristics, and erosion of electrodes; analysis of optimal configuration of plasma system
- **Outcomes/Deliverables:** Parameters of single gliding arc plasma unit for scaling up to industrial size; optimal plasma scheme of water treatment
- **Project Duration, Budget:** 1 year/ 40K

Need and Relevance

- Non-equilibrium gliding arcs in reverse vortex (Tornado) flow (GAT) at low power level (1-3kW) are proved to be a highly efficient plasma stimulators of several plasma chemical and plasma catalytic processes, including hydrogen/syngas generation from municipal wastes, biomass, coal and organic wastes, exhaust gas cleaning, fuel desulfurization and water treatment.
- Large scale application and commercialization of this technology require scaling-up of the non-equilibrium GA to a power of at least 300kW, which corresponds to H2/syngas production on the power level up to 30MW.

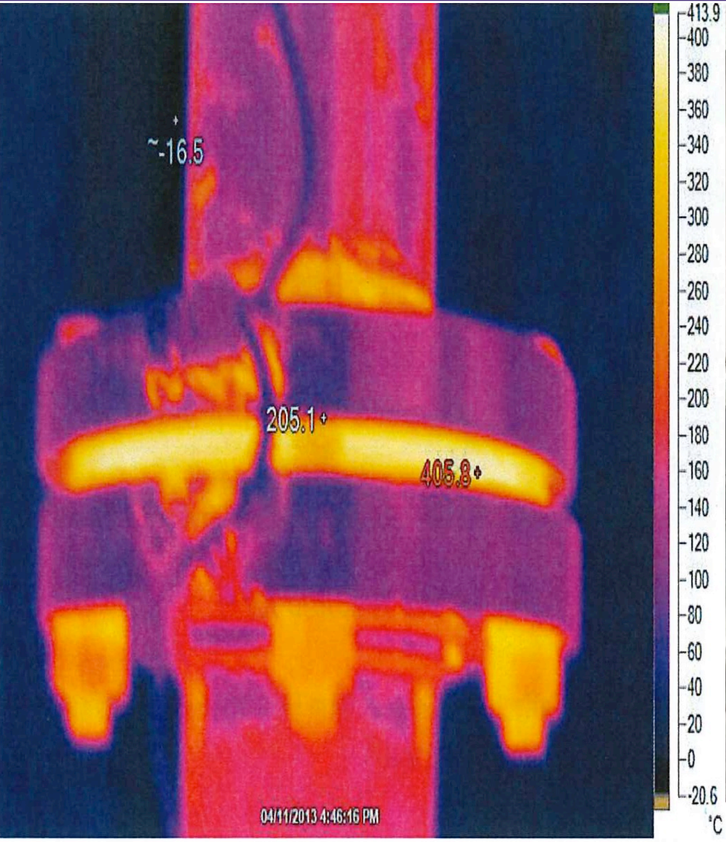
Previous Experience

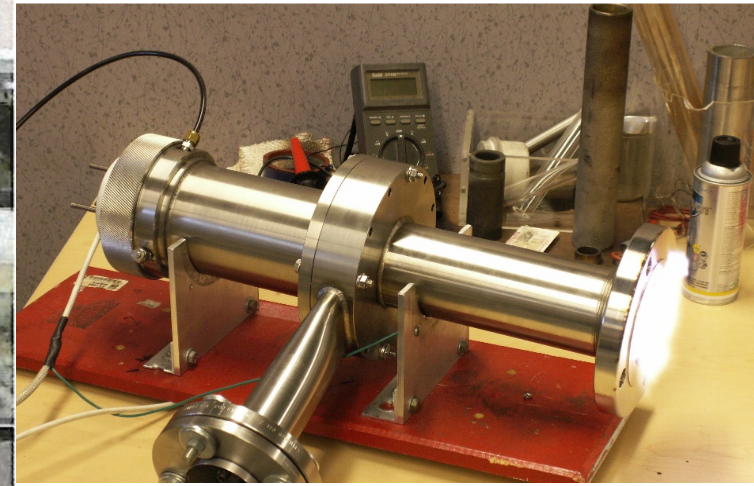
Development of 10 kW Plasma Reformer for Municipal Waste Gasification Plant in Ottawa, Canada (Plasco)

- The gliding arc plasma reformer was designed for efficient reforming of high temperature (greater than 650 °C) "dirty" pyrogas containing heavy hydrocarbons, air, and water vapor into clean synthesis gas containing H_2, CO and N_2. Reformer was installed and continuously operated for 4 months in high temperature exhaust manifold of municipal waste gasifier.

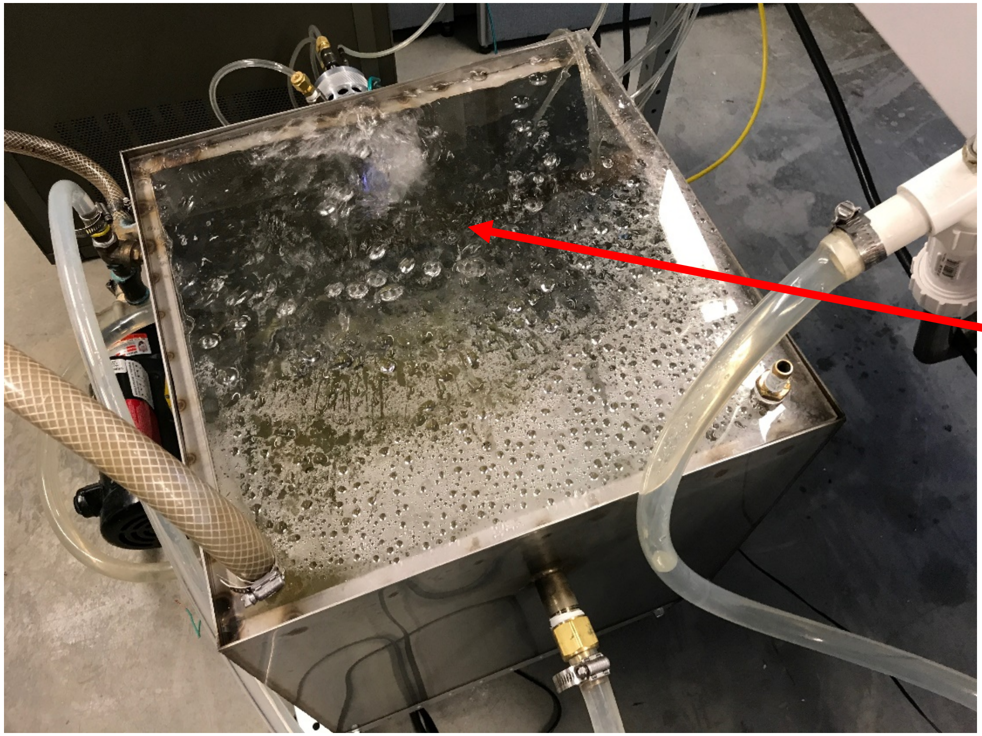
Previous Experience

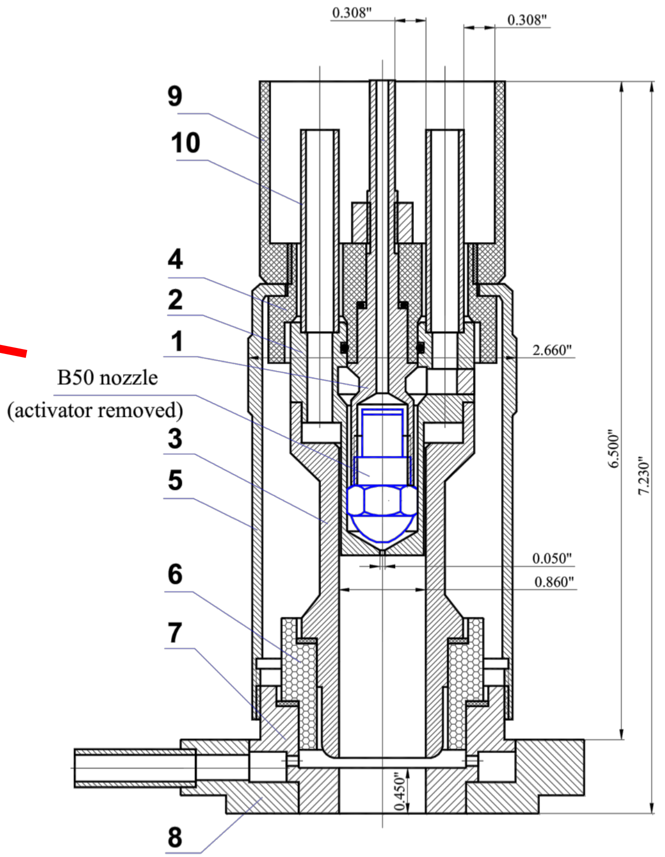
Development of 10 kW Plasma Reformer for Municipal Waste Gasification Plant in Ottawa, Canada (Plasco)





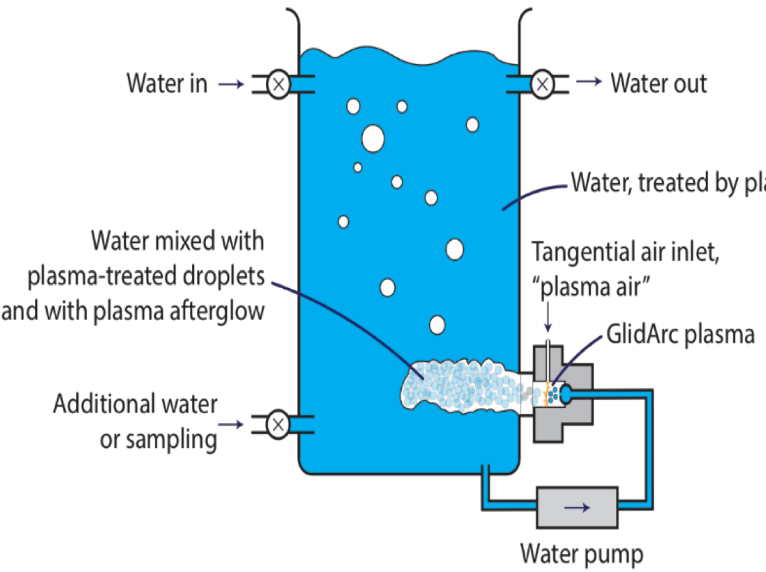
200L submerged GA plasma-water treatment system:
Plasma Hydroponics



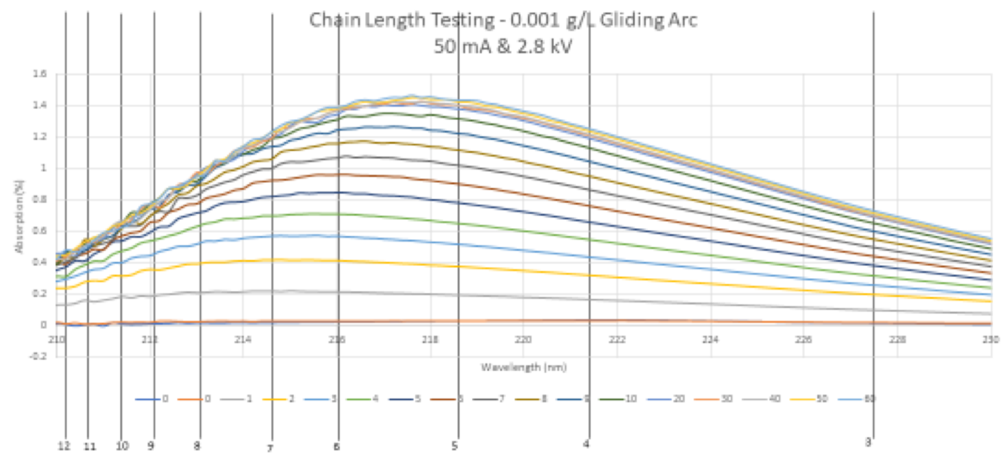


- Water flow through plasma: 100 ml/min
- Recirculation rate: 85 liters / hour
- pH decreased by 1 points / hour

Plasma Removal of PFOA from Water



UV Detection – 2018-12-19 015 Experiment



Preliminary Energy Cost of PFOA removal – 10-20 kJ/L

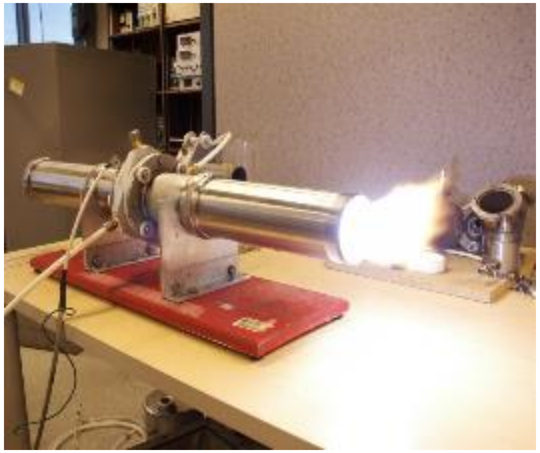
Project Goals & Objectives

- Effective non equilibrium operation of GAT requires cold secondary electron emission mechanism of providing electrons to the gliding non equilibrium arc channel. Non equilibrium GAT regime is limited by transition from cold secondary electron emission to hot and highly erosive thermionic emission taking place at elevated currents and powers. Identification of maximum current level (and related levels of plasma power) preventing transition to thermionic emission at different arc motion modes is a major **scientific goal** of the project.
- Further increase of GAT power can be provided by increase of voltage and special multistage configuration of GAT reactor. Identification of optimal schemes of combining single plasma units into complex GAT plasma configurations without loosing required level of plasma non equilibrium is a major **engineering goal** of the project.

Approach/Methods

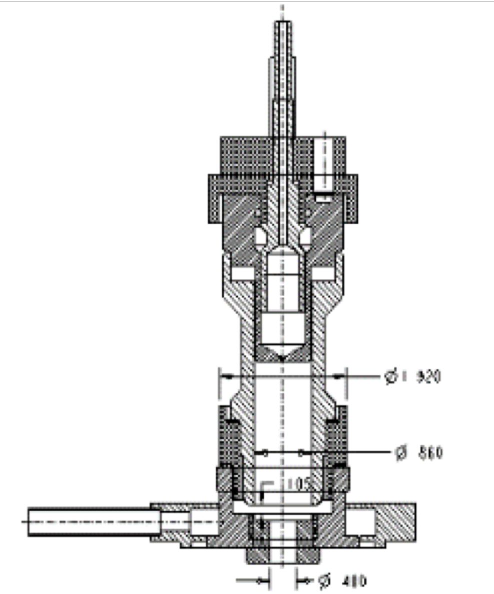
Measurement of:

- V-I characteristics,
- electrodes erosion,
- inner electrodes temperature

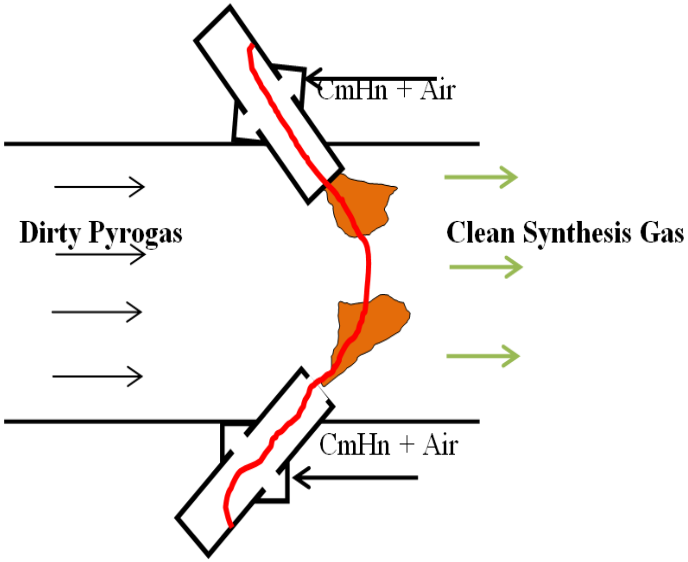


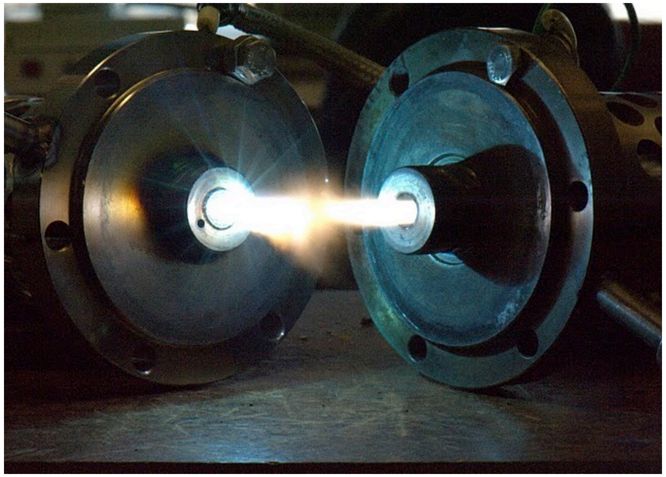
Different scaling up schematics

Reverse Vortex



Series Connection



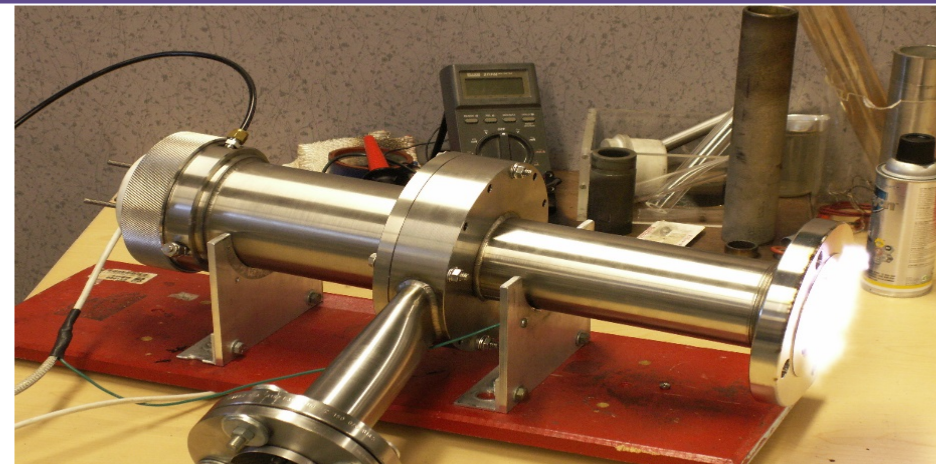


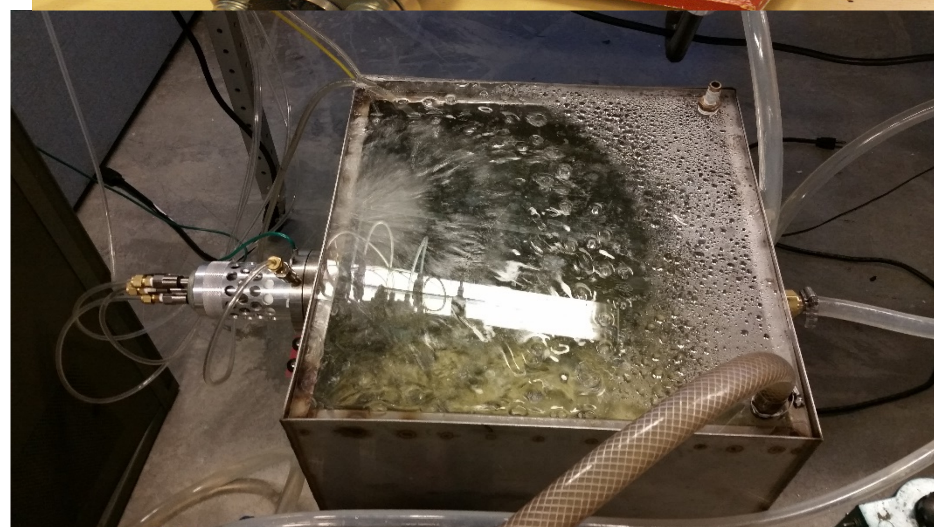
Outcomes/Deliverables

- **Identification of maximum current level (and related levels of plasma power) preventing transition to thermionic emission at different arc motion modes**
- **Identification of optimal schemes of combining single plasma units into complex GAT plasma configurations without loosing the required level of plasma non equilibrium**

Impact

Scaling-up of the non-equilibrium GA to a power of at least 300kW, which corresponds to H2/syngas production on the power level up to 30MW will open pathway to a large scale application and commercialization of this technology in waste-to-energy and water treatment processes





Project Timeline and Duration

Task / month	1	2	3	4	5	6	7	8	9	10	11	12
1. Measurement of V-I characteristics	x	x	x	x								
2. Measurement of electrodes erosion				x	x	x	x					
3. Testing of scaling-up scheme: reverse vortex							x	x	x	x		
4. Testing of scaling-up scheme: serial connection									x	x	x	x

Project Budget

Item	Cost
Student stipend	$ 20,000.00
Supplies	$ 5,000.00
Purchased services	$ 10,000.00
Equipment	$ 5,000.00
Travel	$ 0.00
Project total*	**$ 40,000**

*C-PEAB leadership recommends not to exceed $40,000/year unless discussed with IAB