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ELECTRO-OPTICS

The Development of Novel Resistive Glass Technology to Simplify and Improve Designs in Analytical Instruments

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Introduction

- In the rapidly evolving analytical instrument market, new applications are constantly being developed. Twenty five years ago, mass spectrometers were primarily research tools. Today, mass spectrometers are used in medical diagnostics, semiconductor manufacturing, environmental monitoring, drug discovery and food processing. Virtually everyone has benefited by the existence of these instruments.

Introduction cont.

- New applications for Mass Spectrometers are constantly emerging; however, many potential applications are very cost sensitive.

- Component and assembly costs often times determine the viability of a new instrument design.

- Simplifying assembly in these instruments could lead to a significant reduction in manufacturing cost.

Discussion

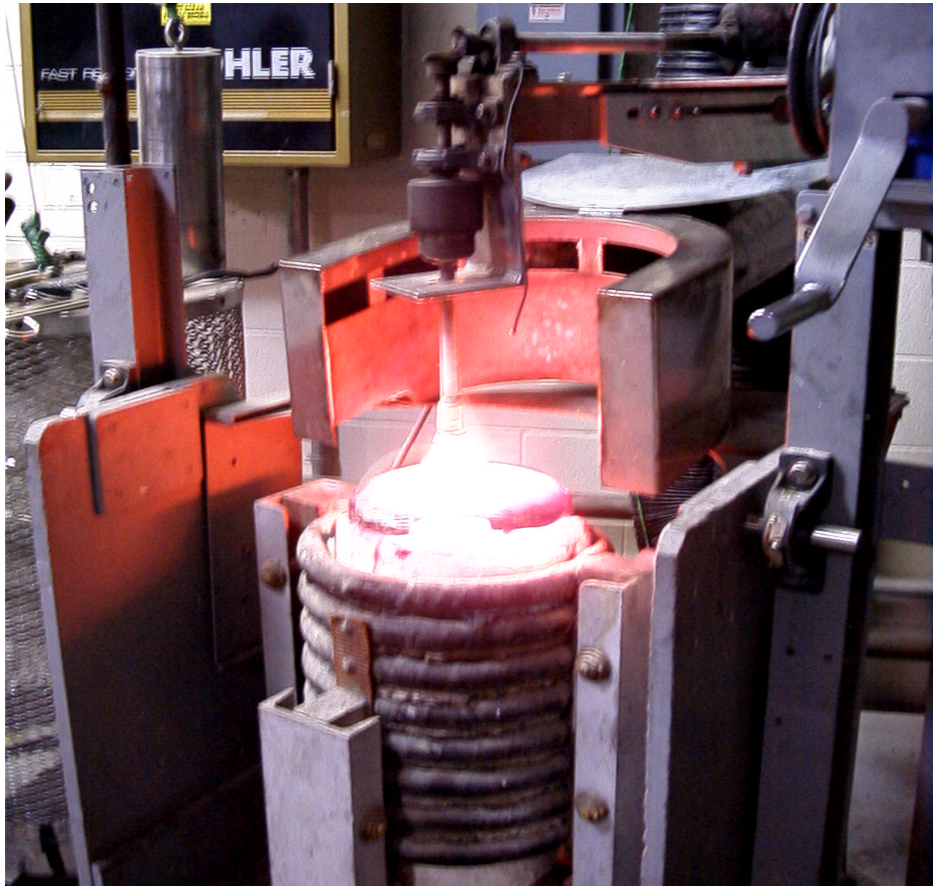
- A number of new materials and tools have been developed in order to facilitate rapid product development and reduced manufacturing cost.

- One example of this is the line of Ion Guides and Drift Tubes made from Resistive Glass.

What is Resistive Glass?

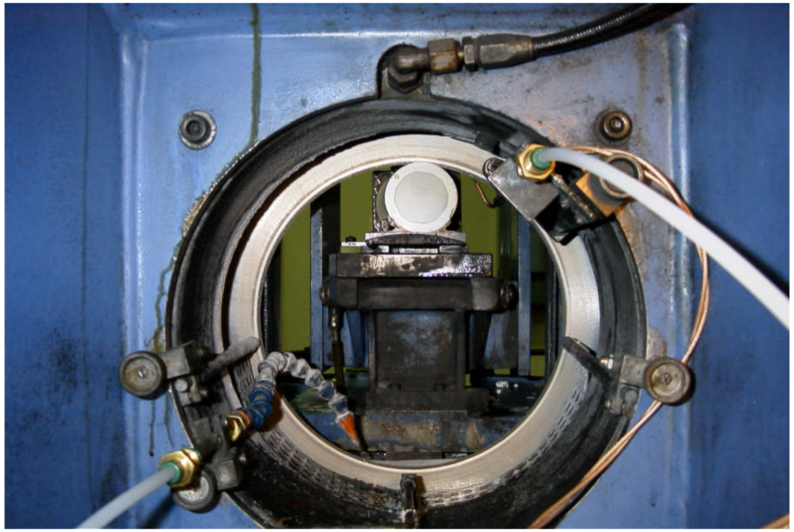
- Resistive Glass Products are geometric glass structures with resistive properties that can be used to create very uniform electric fields of unique shapes in order to guide or direct charged particles.

- They are fabricated from proprietary reduced lead silicate glasses and can have thin film metallization contact points.



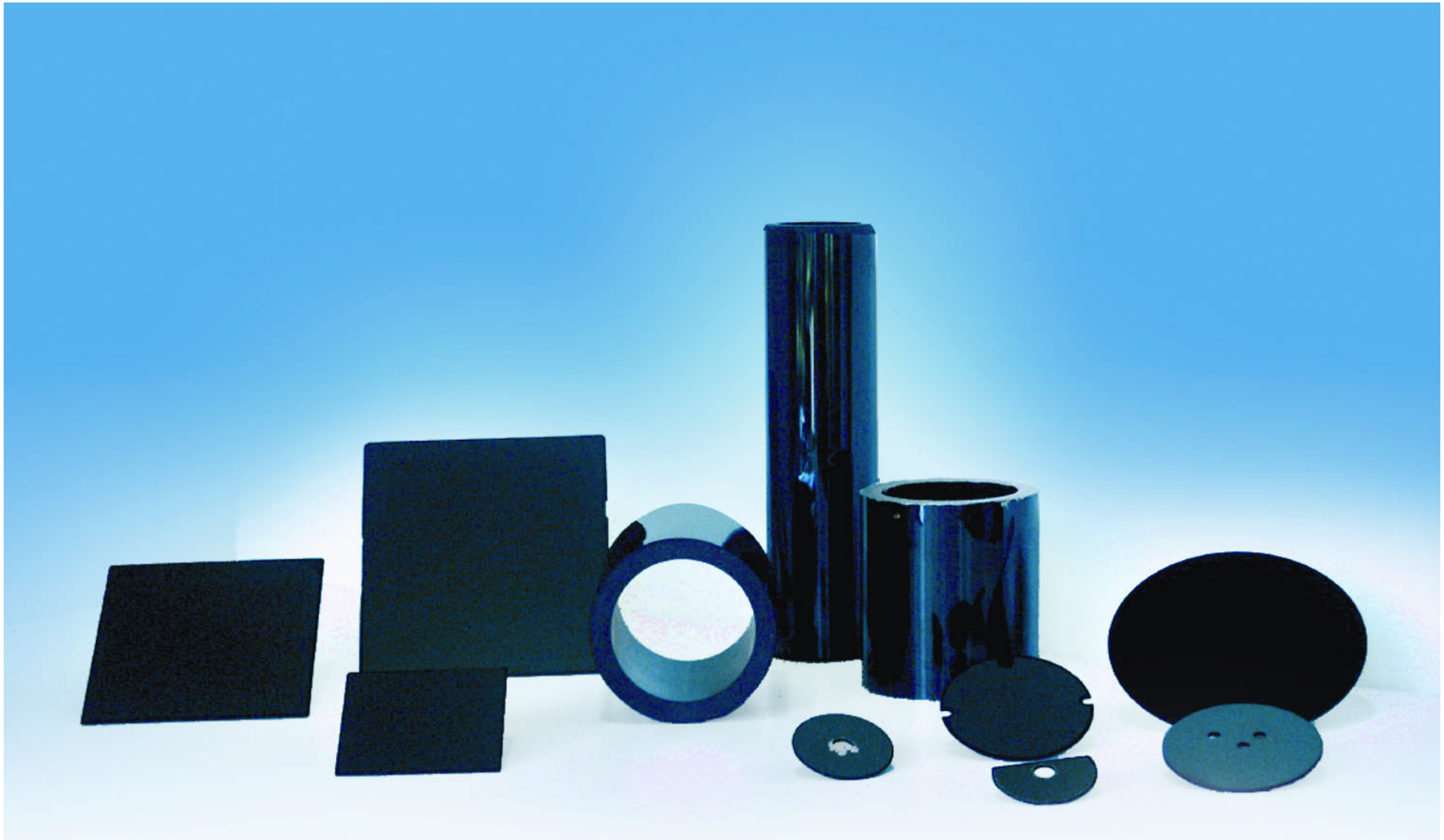
Proprietary lead glasses are produced from high purity raw materials. They are formed into tubes or flat glass and then heat treated to produce a semi-conductive layer on the surface of the glass.

Extrusion and Finishing Operations



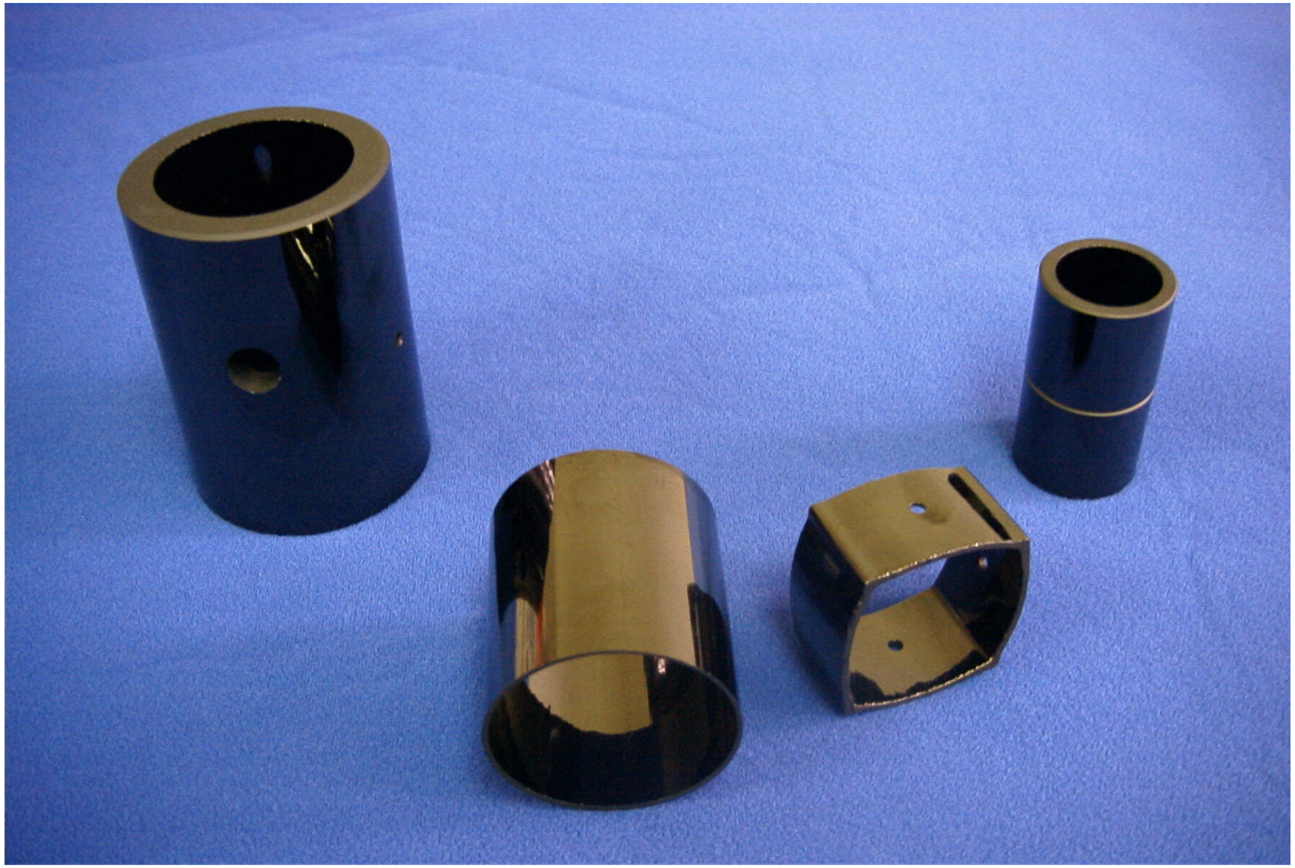
Hydrogen Reduction and Metallization

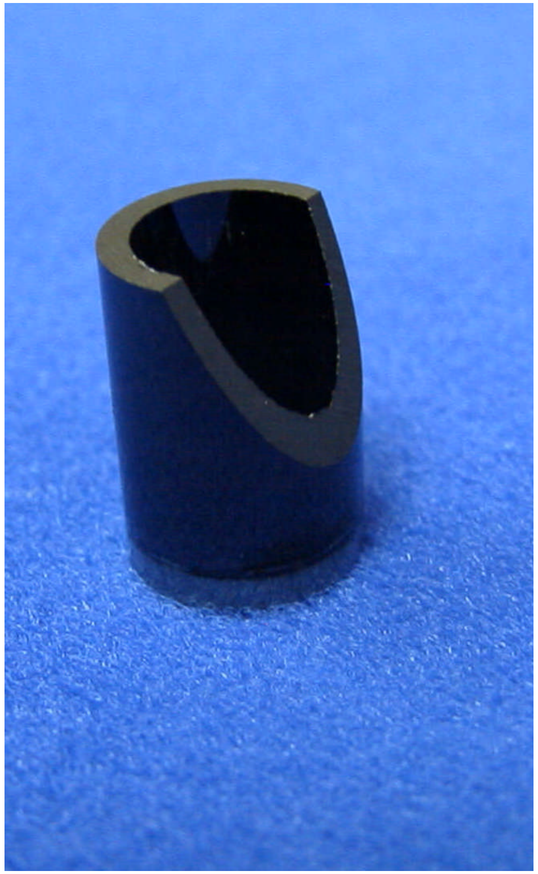
Resistive Glass Formats



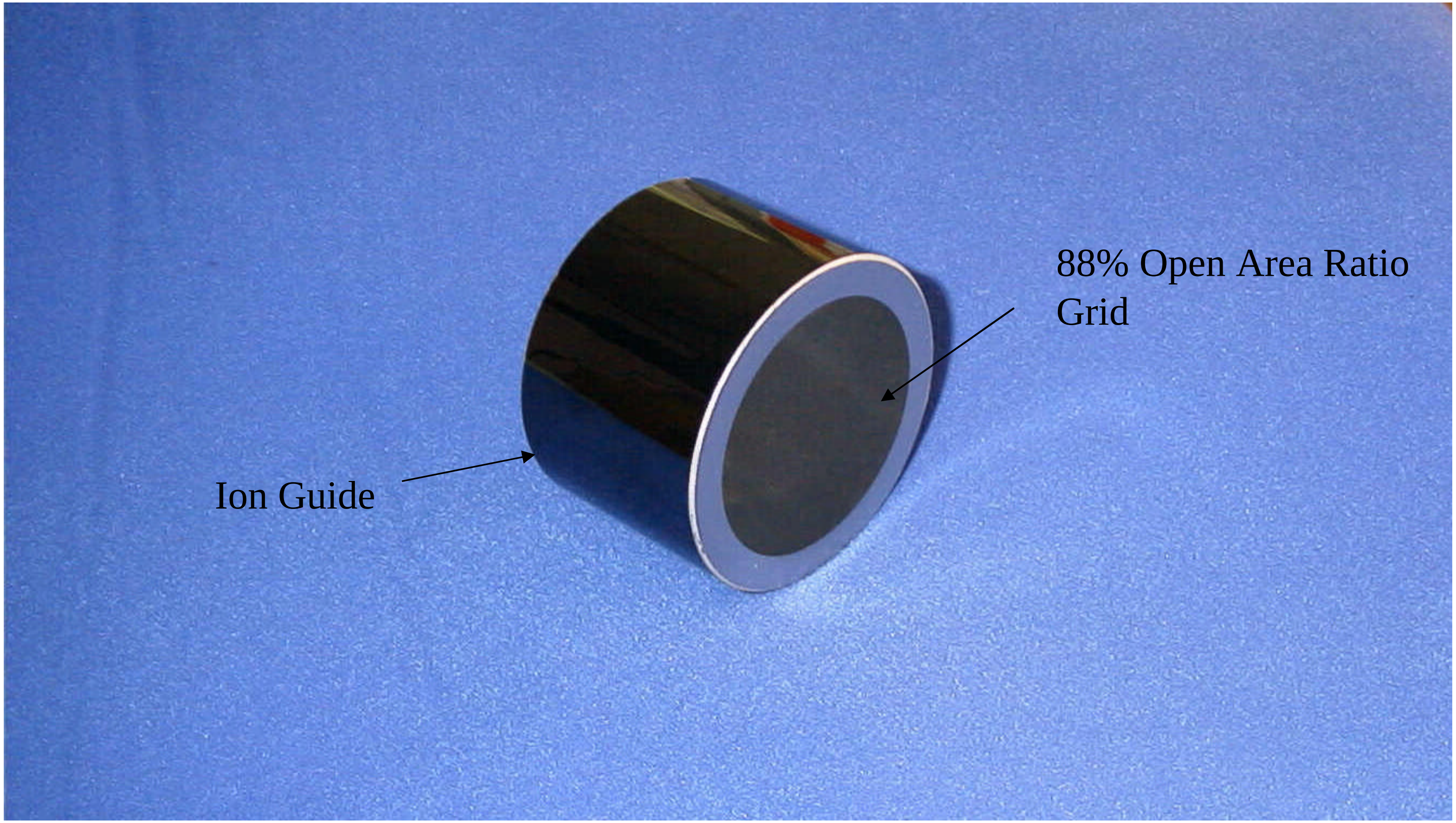
Special Features

Inlet Holes, Rectangular Shapes, and Geometric Shapes



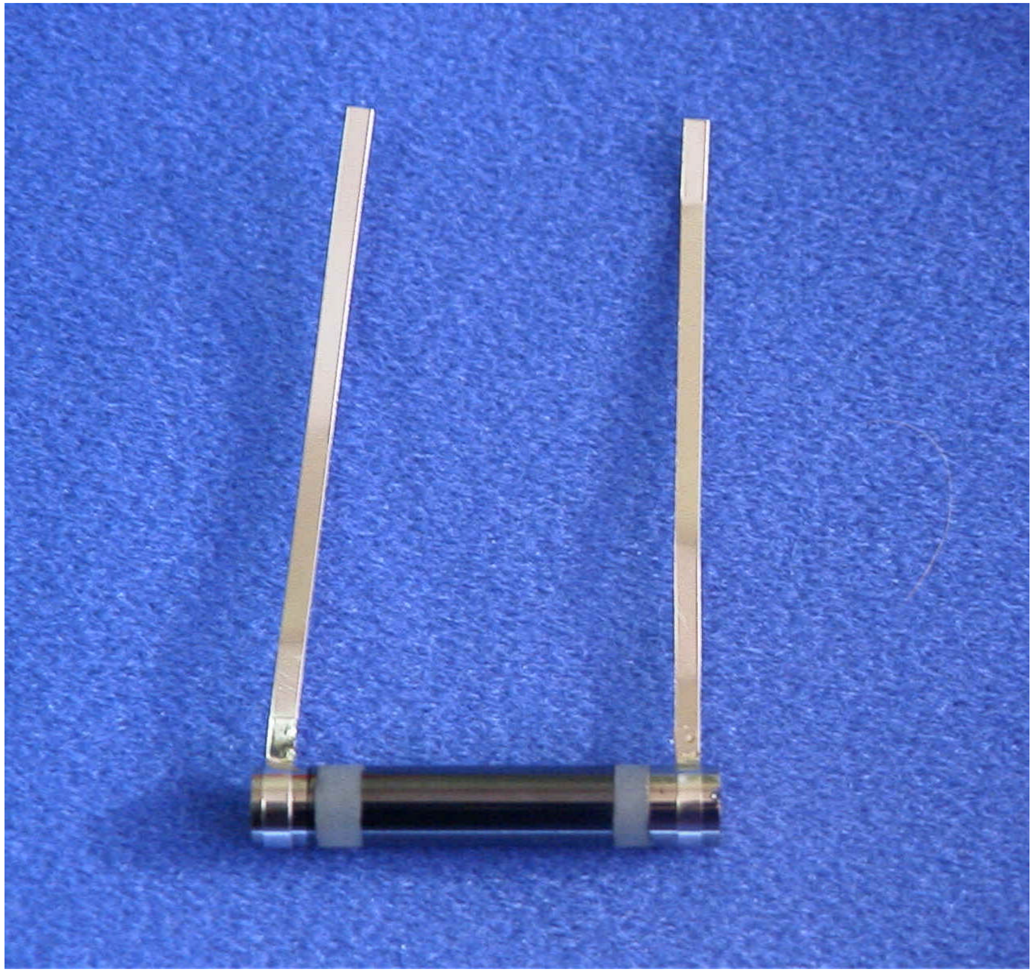


Grids and Ion Gates



Electrical Connections

Flying Leads, Metalized Glass, or Fritted Mechanical Mounts



Material Characteristics

Property	MCP-10 Glass	65-12 Glass
Softening Temperature	642°C	613°C
Operating Temperature Range	-20°C to 400°C	-20°C to 400°C
Density	4.44 g/cm^3	5.07 g/cm^3
Annealing Temperature	480°C	482°C
Temperature Coefficient of Resistivity	~ -0.85% / °C	~ -0.80% / °C
Thermal Expansion Coefficient	78x10^{-7}/ °C	82x10^{-7} / °C
Typical Device Resistance Range	10^9-$10^{11}\Omega$	10^5-$10^9\Omega$

Cross Section of Reduced Glass

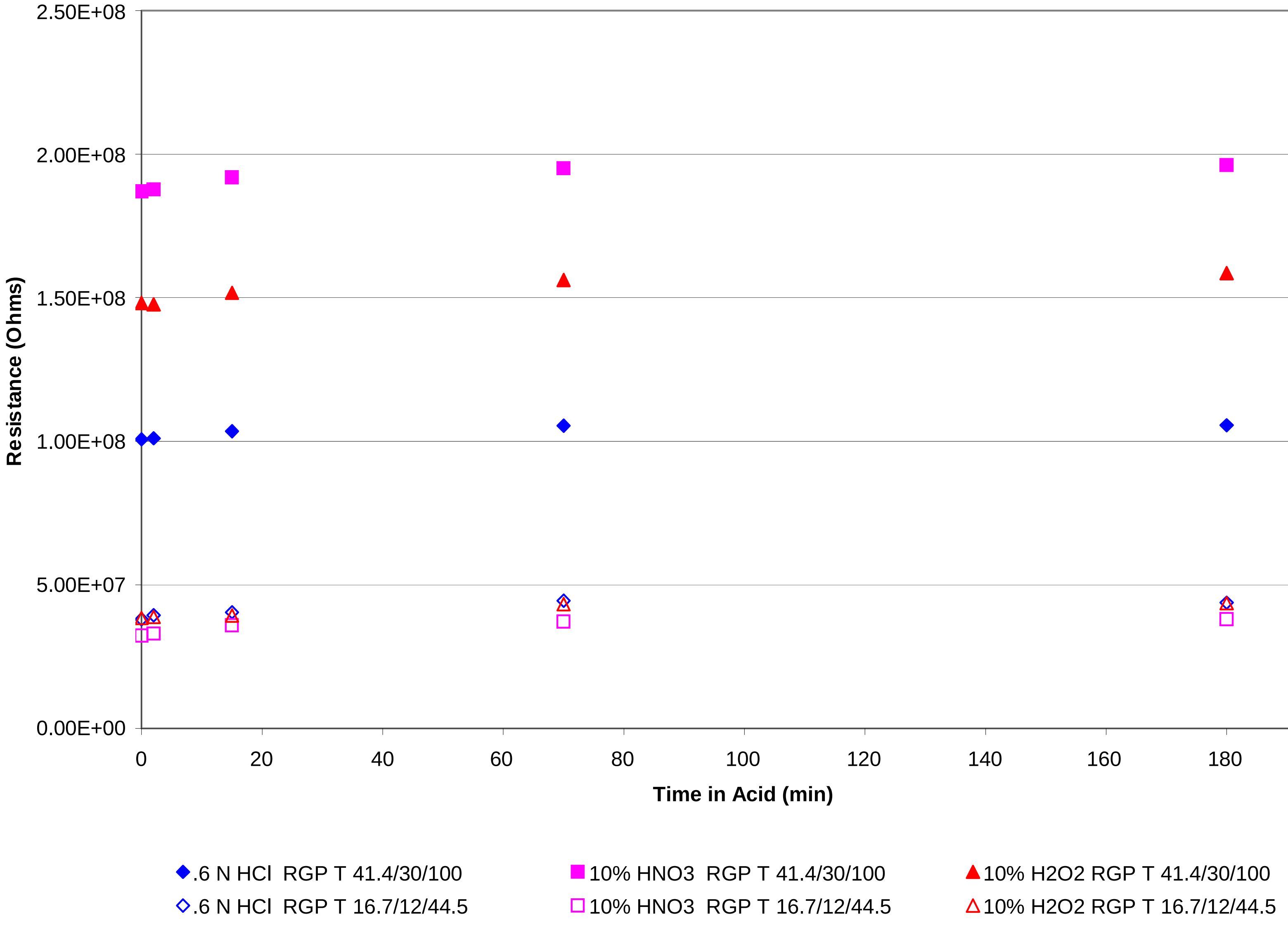
The reduced lead silicate layer is typically a few hundred angstroms thick.

Chemical Durability

- Resistive glass can be cleaned using the following agents without affecting the resistance:
  - Water
  - Methanol
  - Isopropanol
  - Acetone
  - Bristled brushes
  - Steel wool soap pads
- Light to moderate abrasions with sandpaper can be tolerated.
- Significant scuffing of the surface begins to breakdown the resistive surface, increasing the overall resistivity of the piece.
- Resistive glass tubes were soaked in solutions of 0.6 N HCl, 10% HNO_3, and 10% H_2O_2. The data on the following slide shows that a slight increase in resistance is seen with direct exposure to acid solutions over time.
- After 3 hours of exposure the increase in resistance was between 5% and 10%.

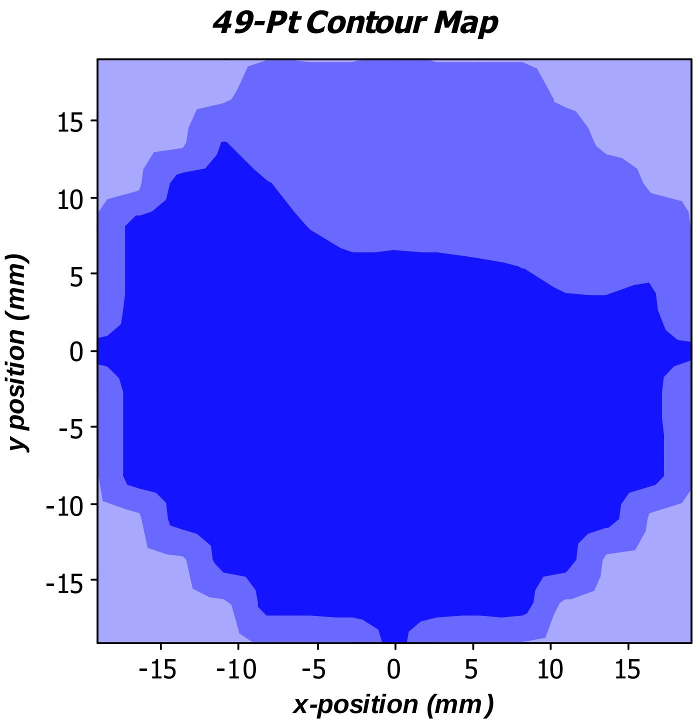
Chemical Durability:

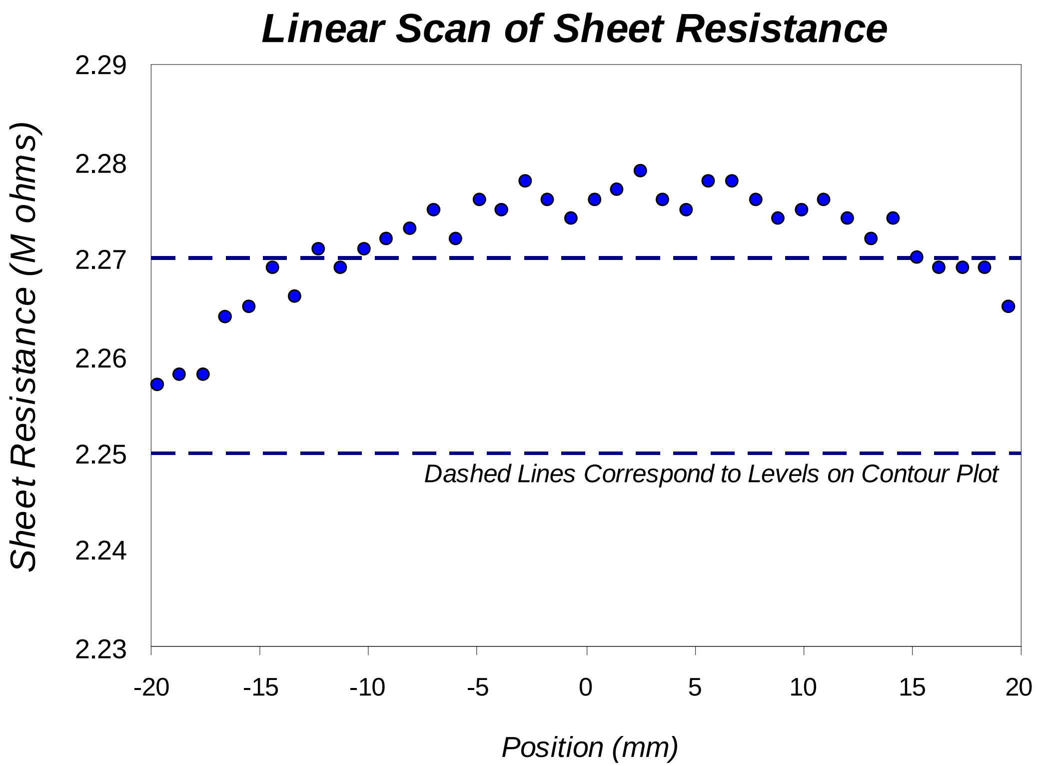
Change in resistance with time in various acid solutions



Resistance Uniformity: Flat Plate

Measured with a 4-Point Probe

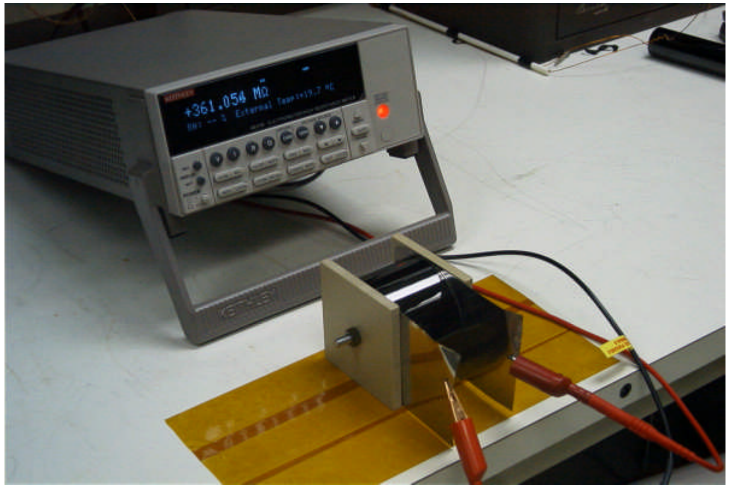


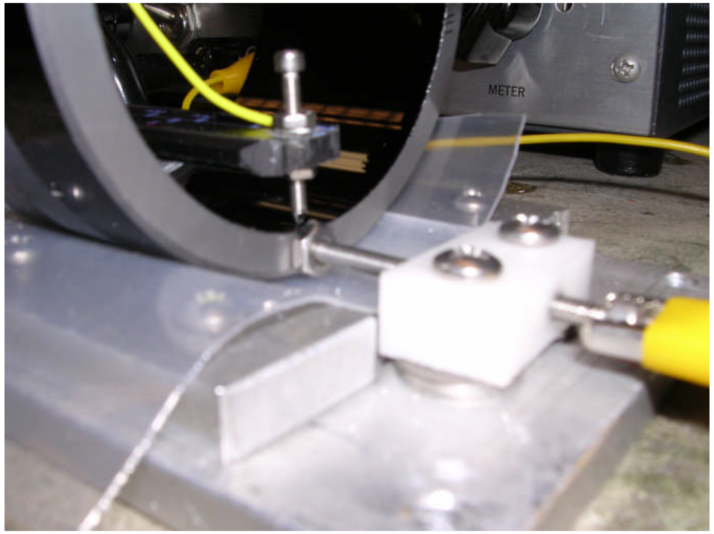


- Sheet resistance of a flat sample measured with a Prometrix RS-55 4-point probe.
- Standard deviation = 0.407%   Total Range ± 2%

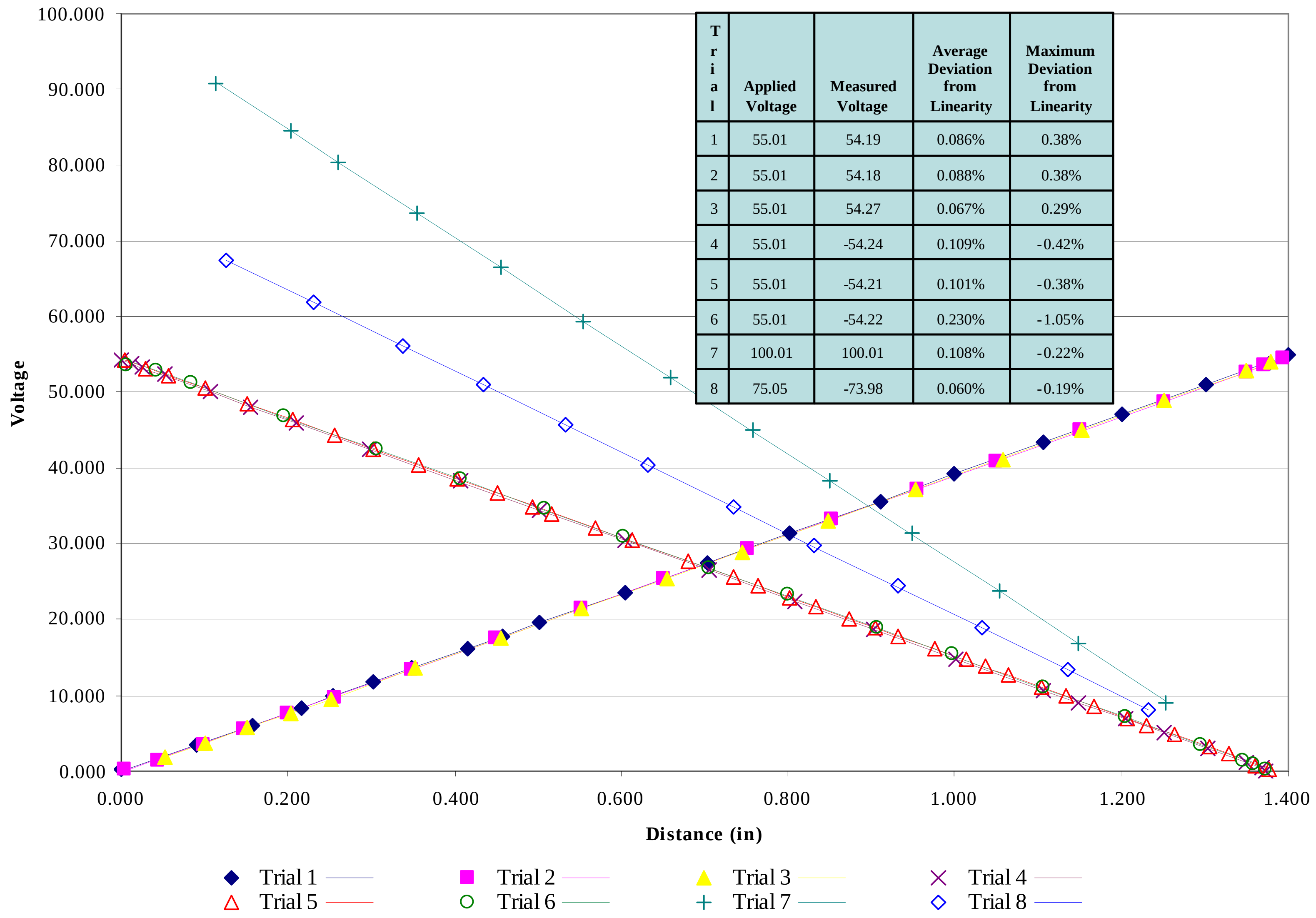
Resistance Uniformity Measurement System: Tubing

- A DC Voltage was applied across the tube.
- The voltage was measured as a function of distance across length of tube.
- The voltage inside the tube was probed by a sharpened screw attached to the end of the digital caliper slide.
- The voltage was measured by a digital electrometer.
- A linear regression line was fit through each set of data. The data was subtracted from this fitted line to obtain the residuals.
- The residuals were divided by the applied voltage to obtain a percent deviation.



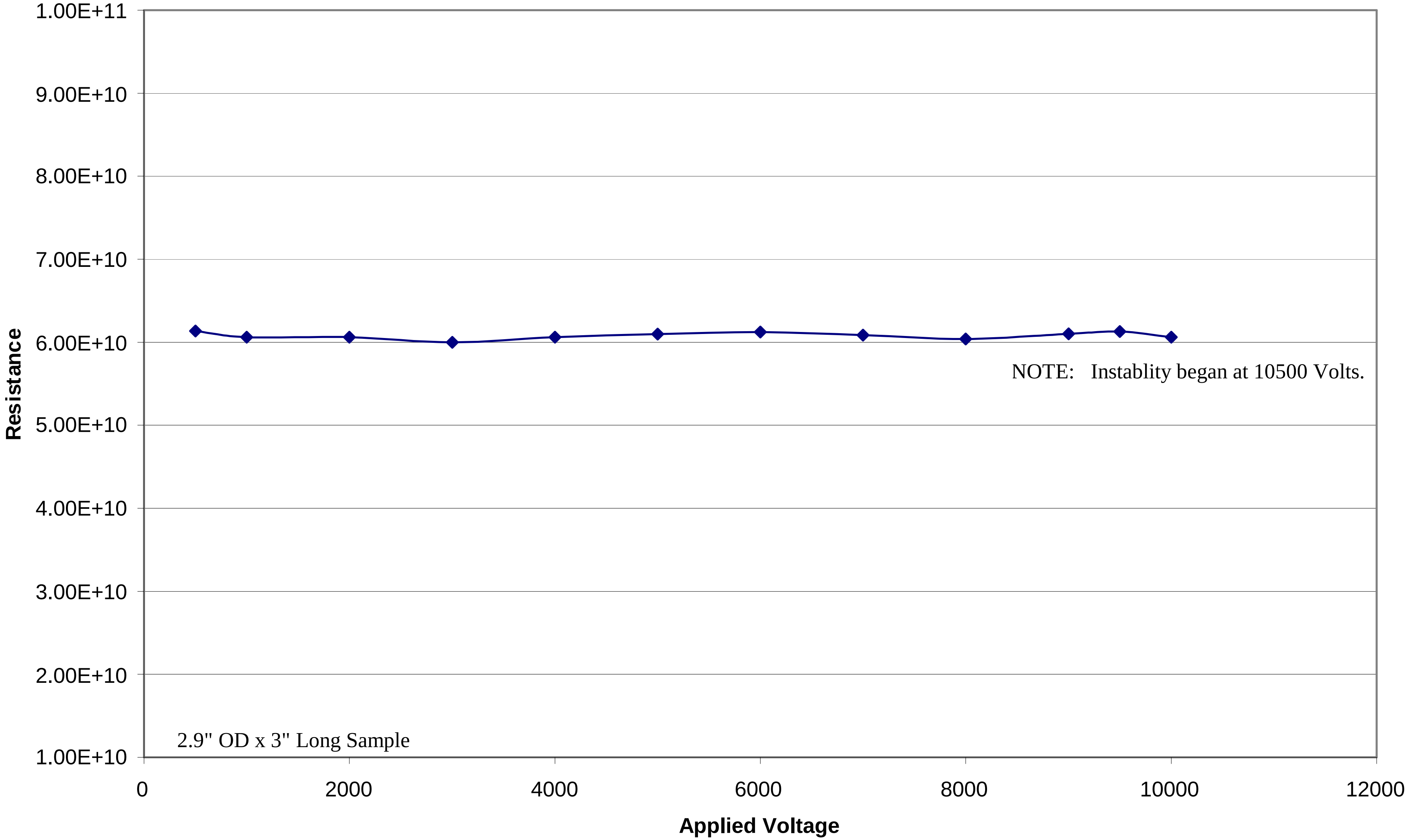


Resistance Uniformity Data: Tubing

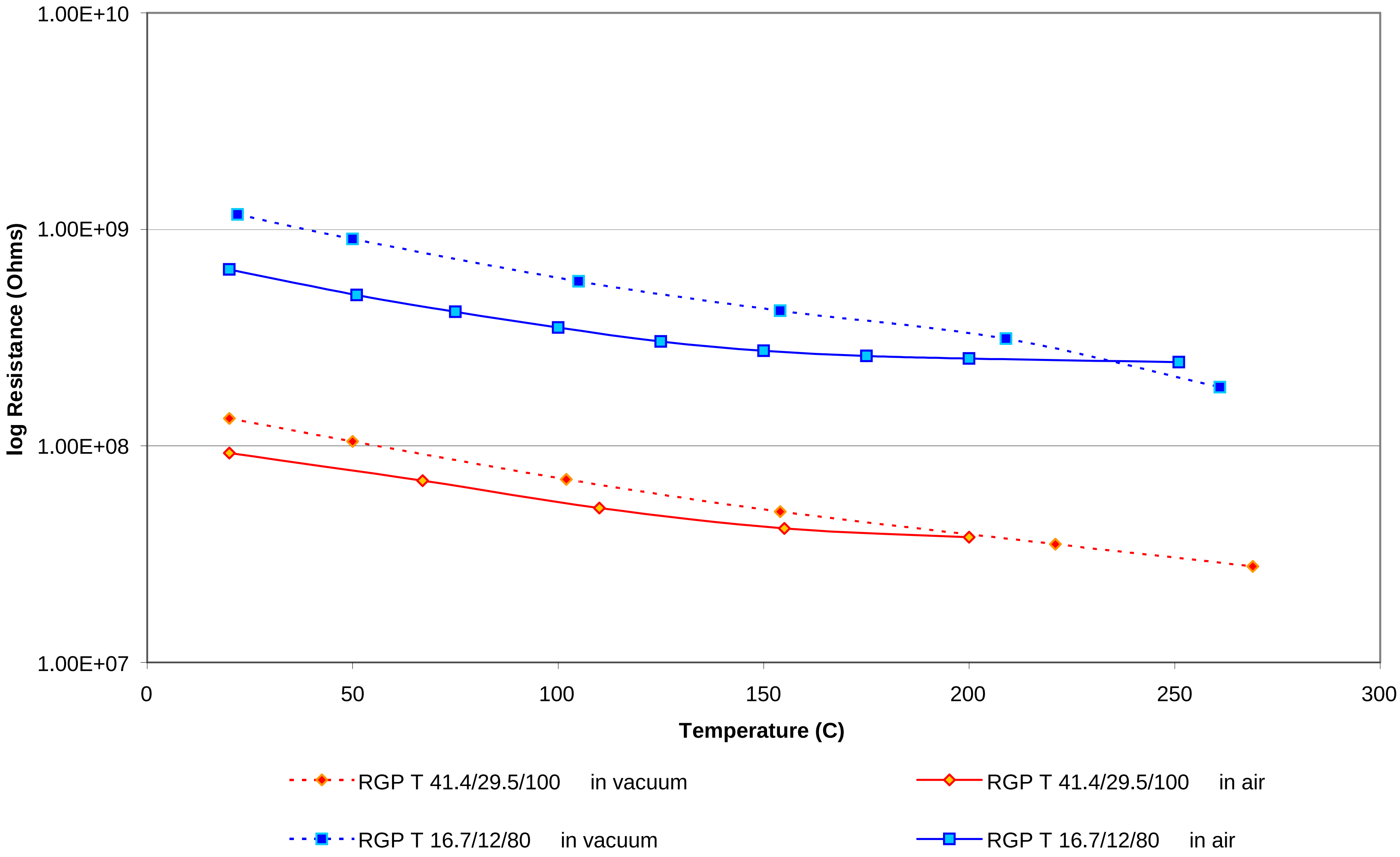


Trial	Applied Voltage	Measured Voltage	Average Deviation from Linearity	Maximum Deviation from Linearity
1	55.01	54.19	0.086%	0.38%
2	55.01	54.18	0.088%	0.38%
3	55.01	54.27	0.067%	0.29%
4	55.01	-54.24	0.109%	-0.42%
5	55.01	-54.21	0.101%	-0.38%
6	55.01	-54.22	0.230%	-1.05%
7	100.01	100.01	0.108%	-0.22%
8	75.05	-73.98	0.060%	-0.19%

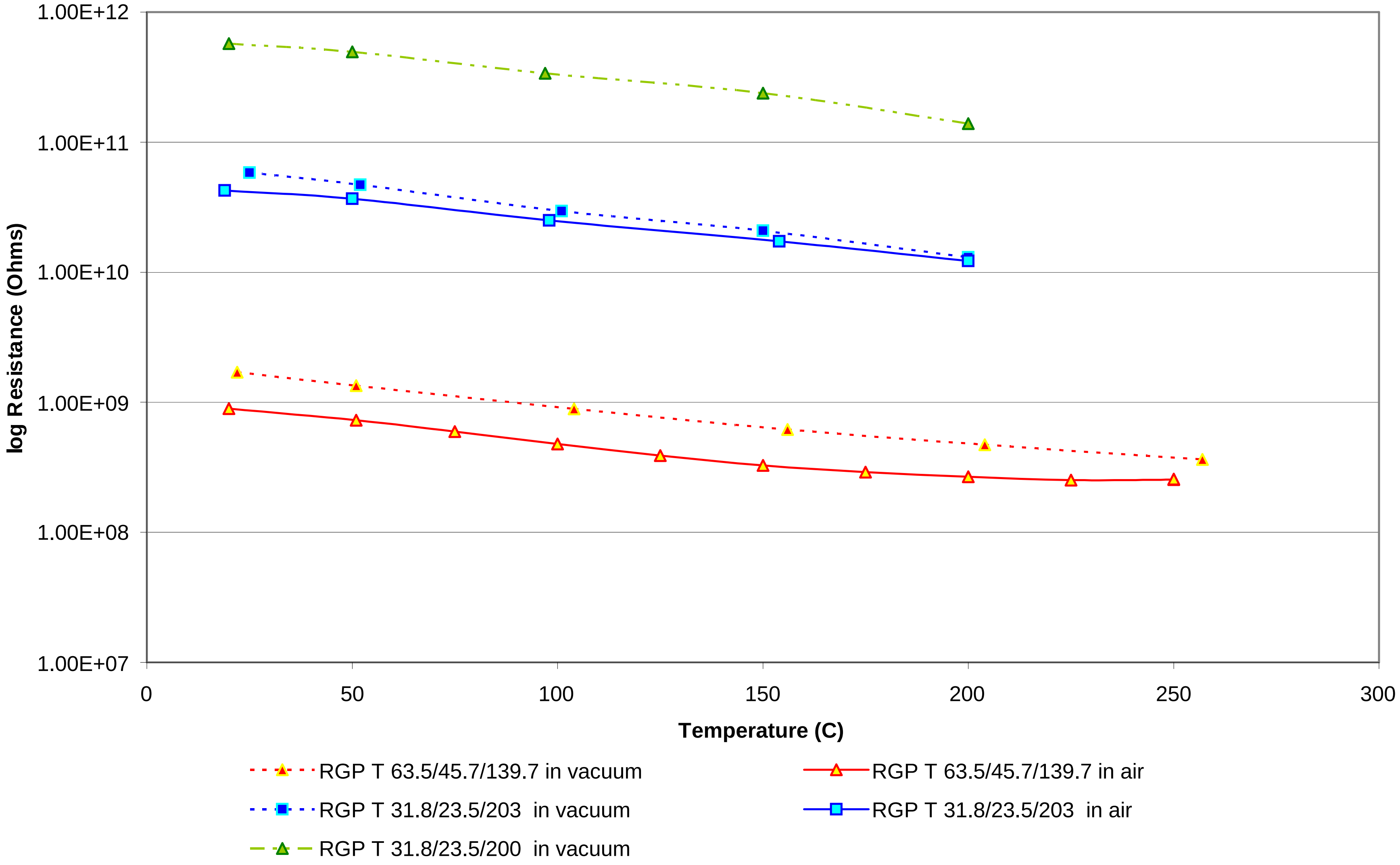
High Voltage Breakdown



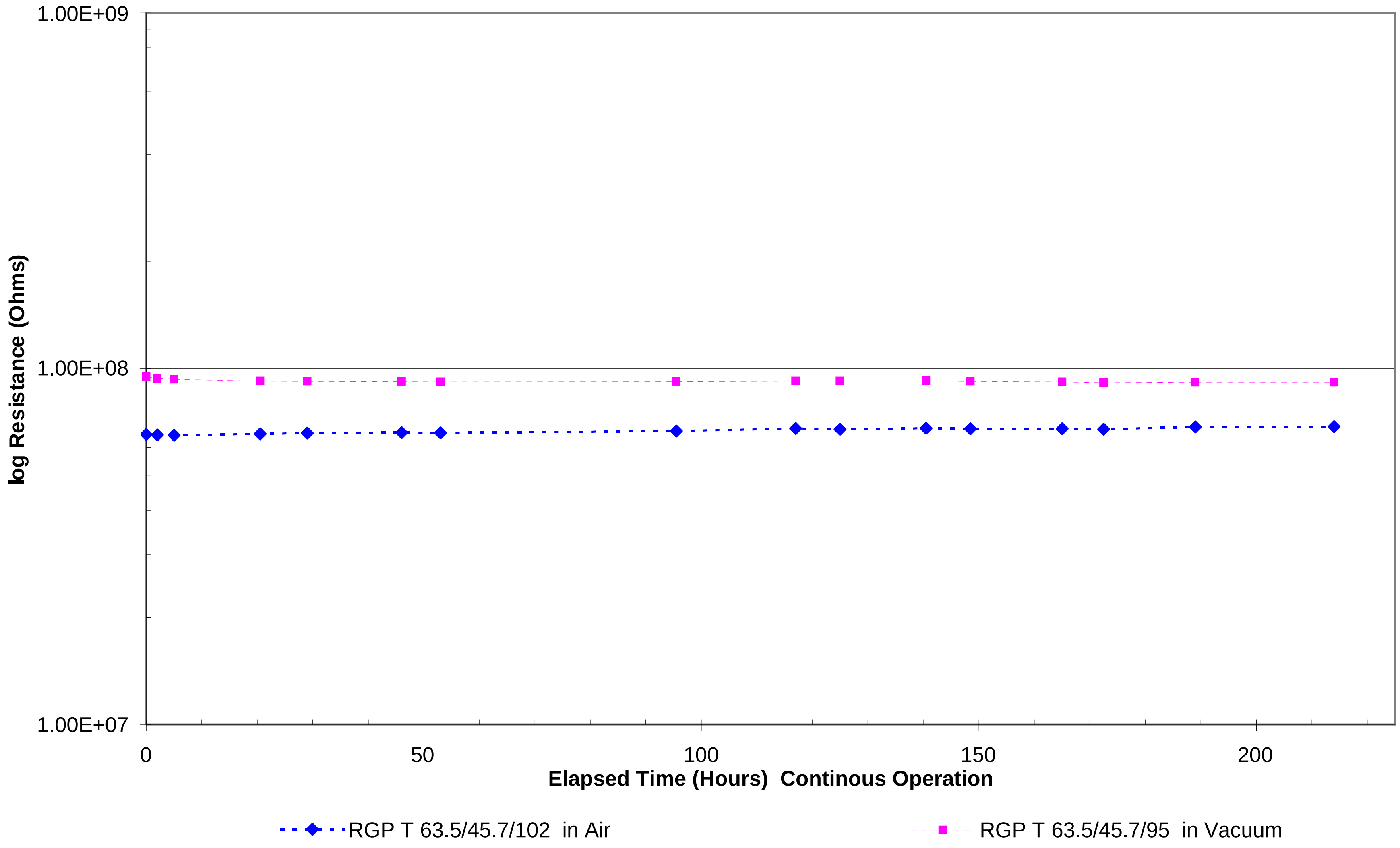
Resistance as a Function of Temperature: 65-12 Glass



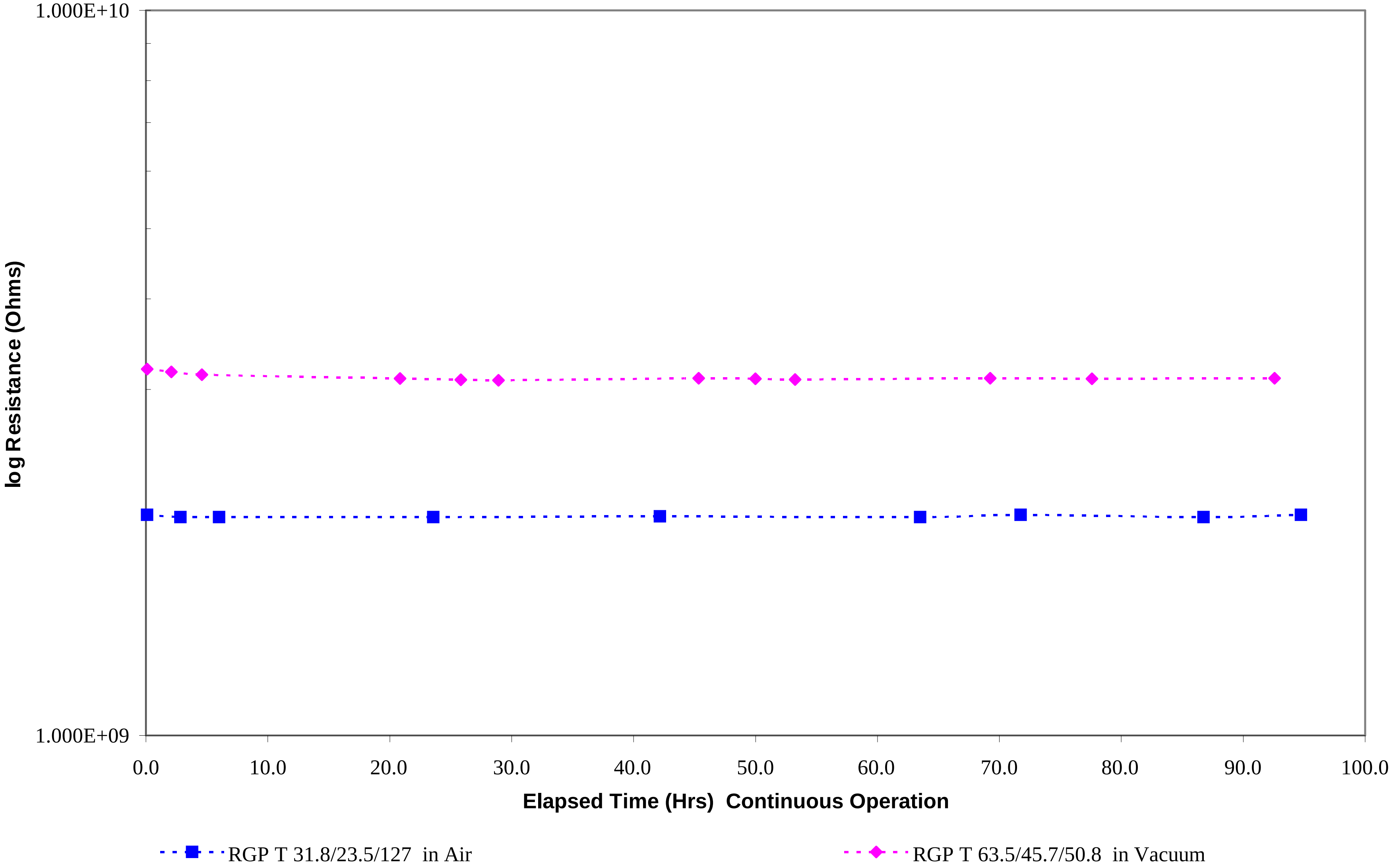
Resistance as a Function of Temperature: MCP-10 Glass



Resistance Stability: 65-12 Glass



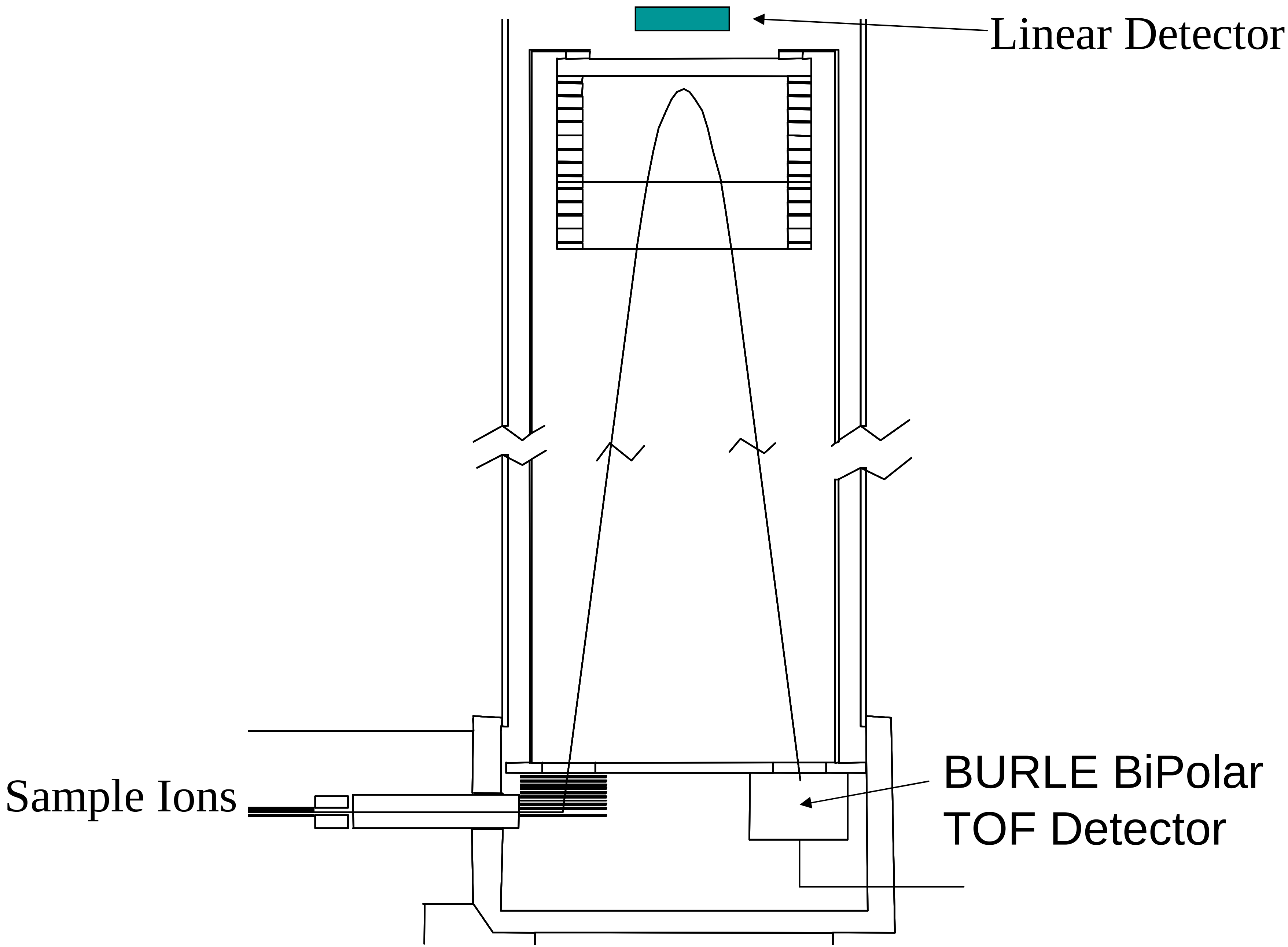
Resistance Stability: MCP-10 Glass



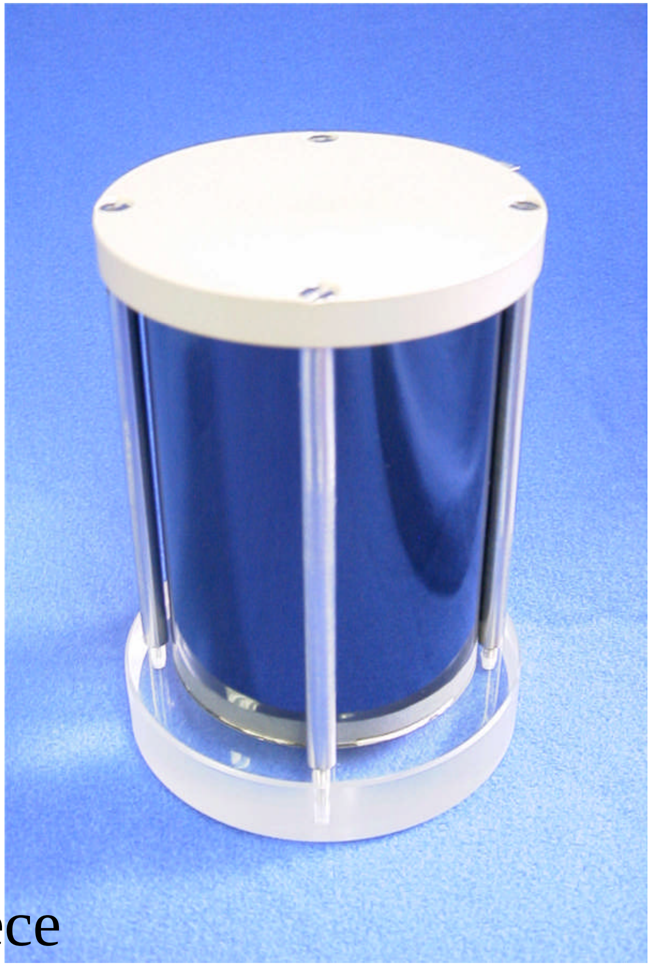
Potential Resistive Glass Applications

- Ion Mirrors (Reflectron Lens)
- High Voltage Dividers
- Collision Cells for CI and Linear Reaction Cells
- Ion Guides
- Conversion Dynodes
- Drift Tubes for Ion Mobility Spectrometers

Typical Reflectron Instrument Geometry



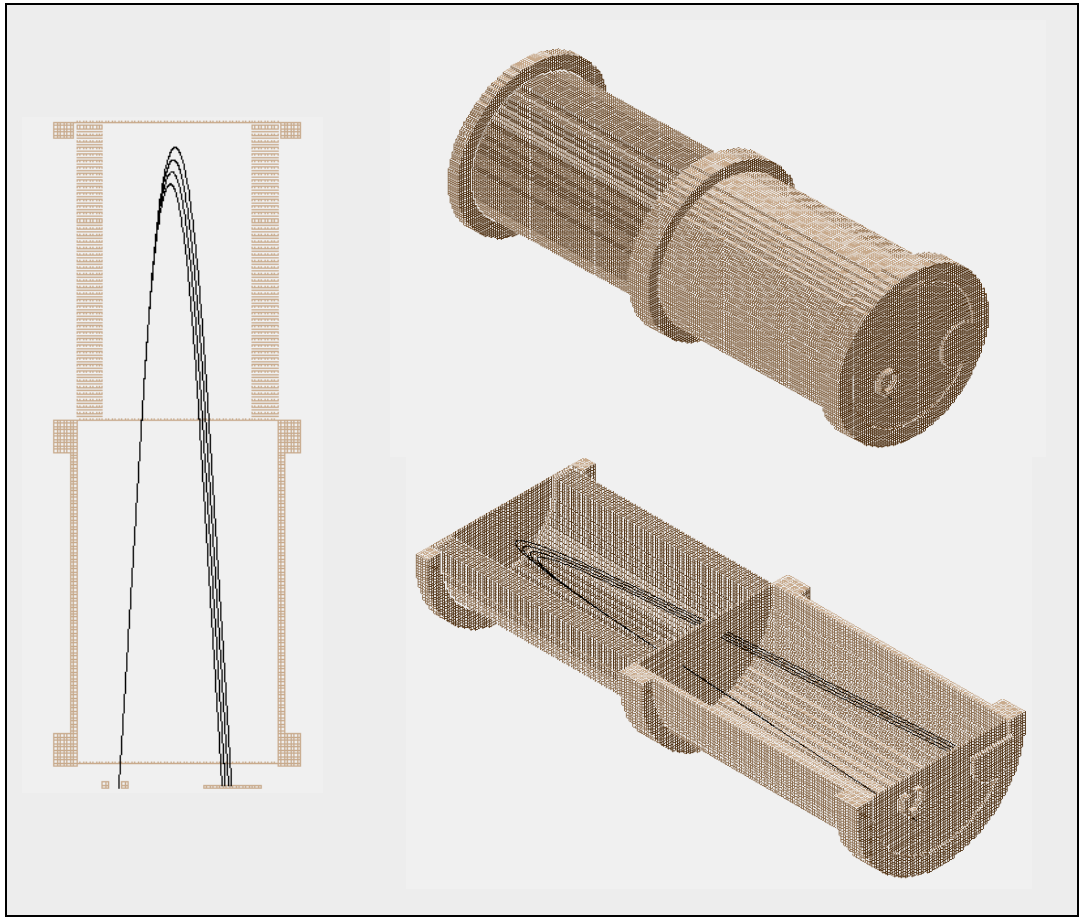
Resistive Glass Reflectron Lens vs. Conventional Reflectron Lens

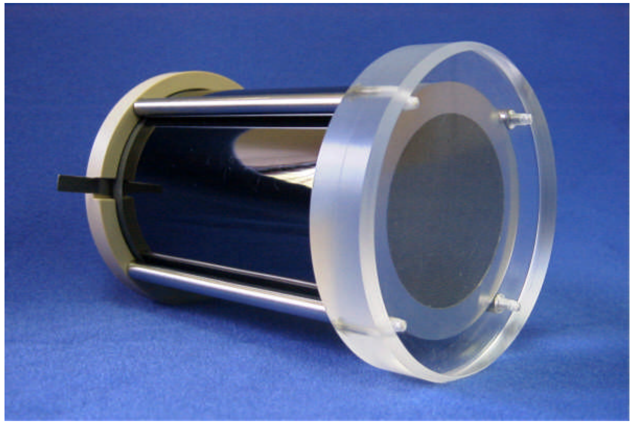


One Piece Design

6 Mounting Posts
20 Metal Rings
108 Ceramic Spacers

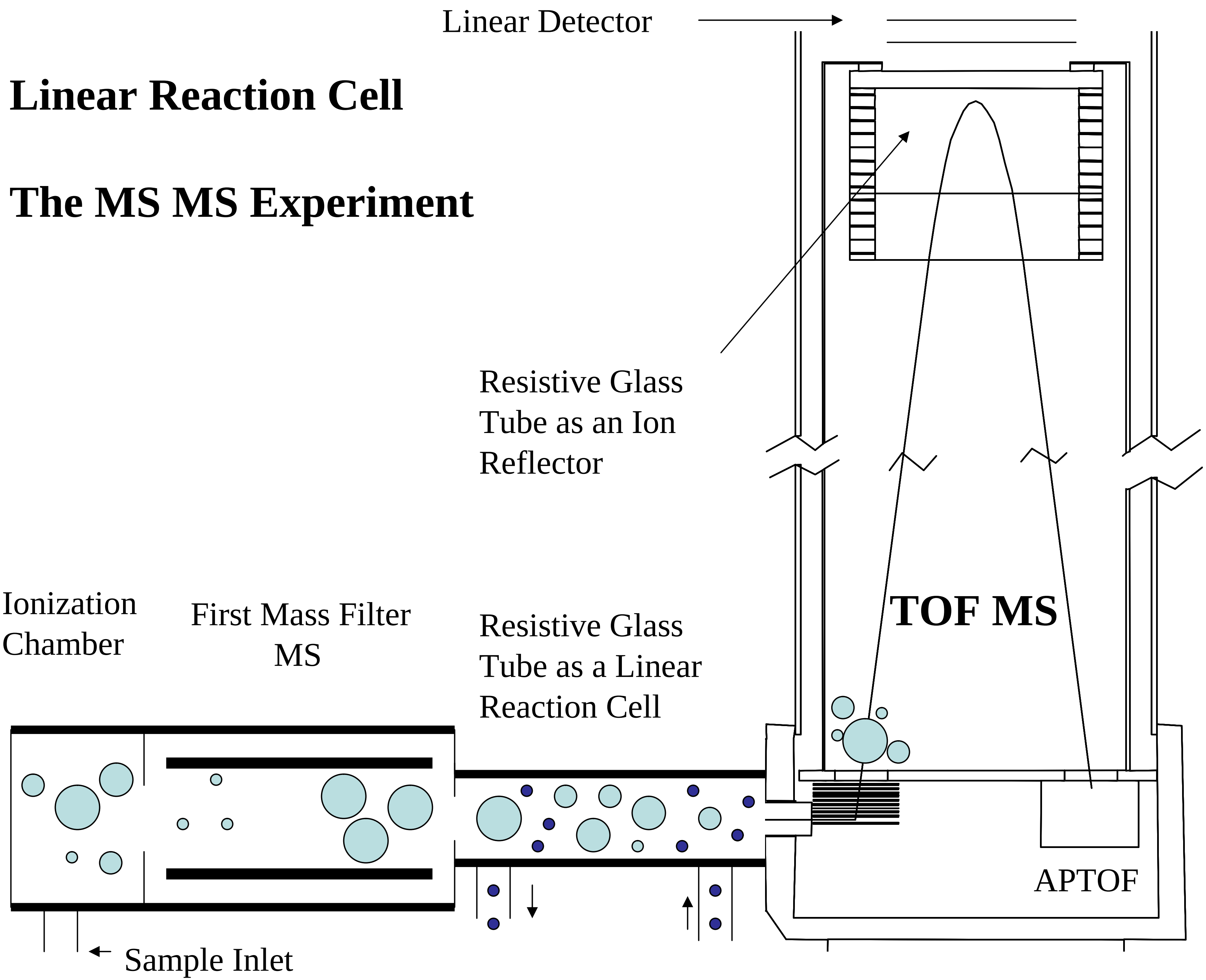
Simion Model: Glass Reflectron Lens



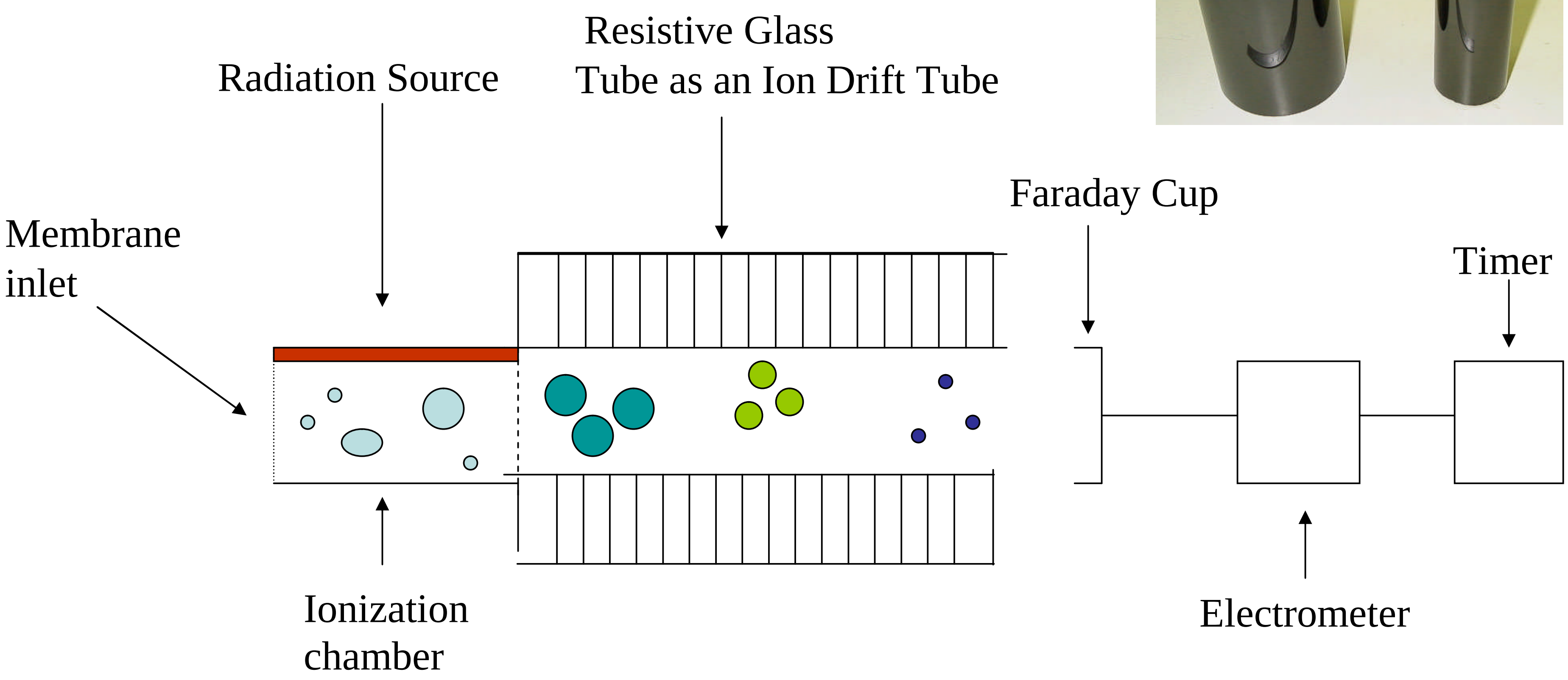


Linear Reaction Cell

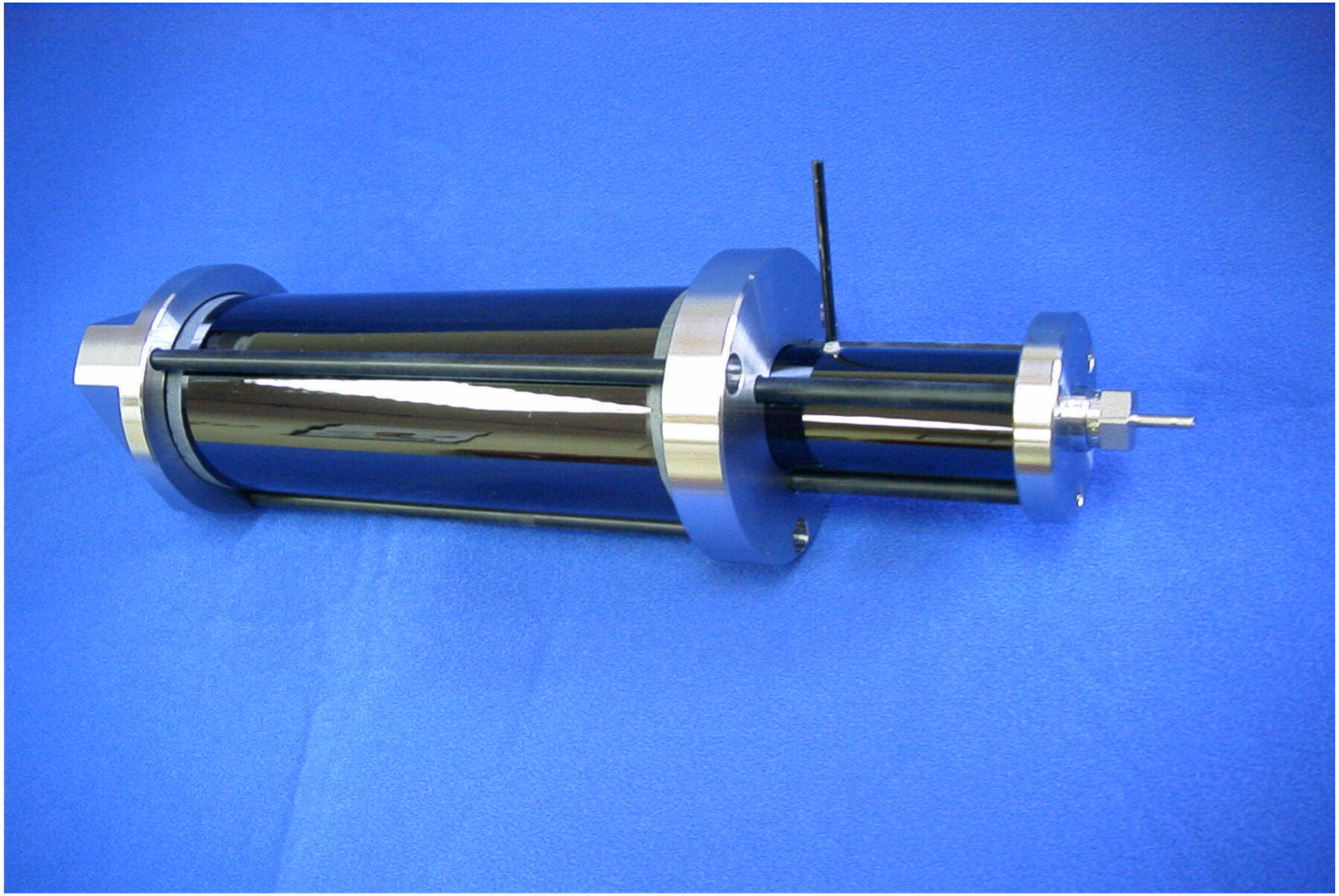
The MS MS Experiment



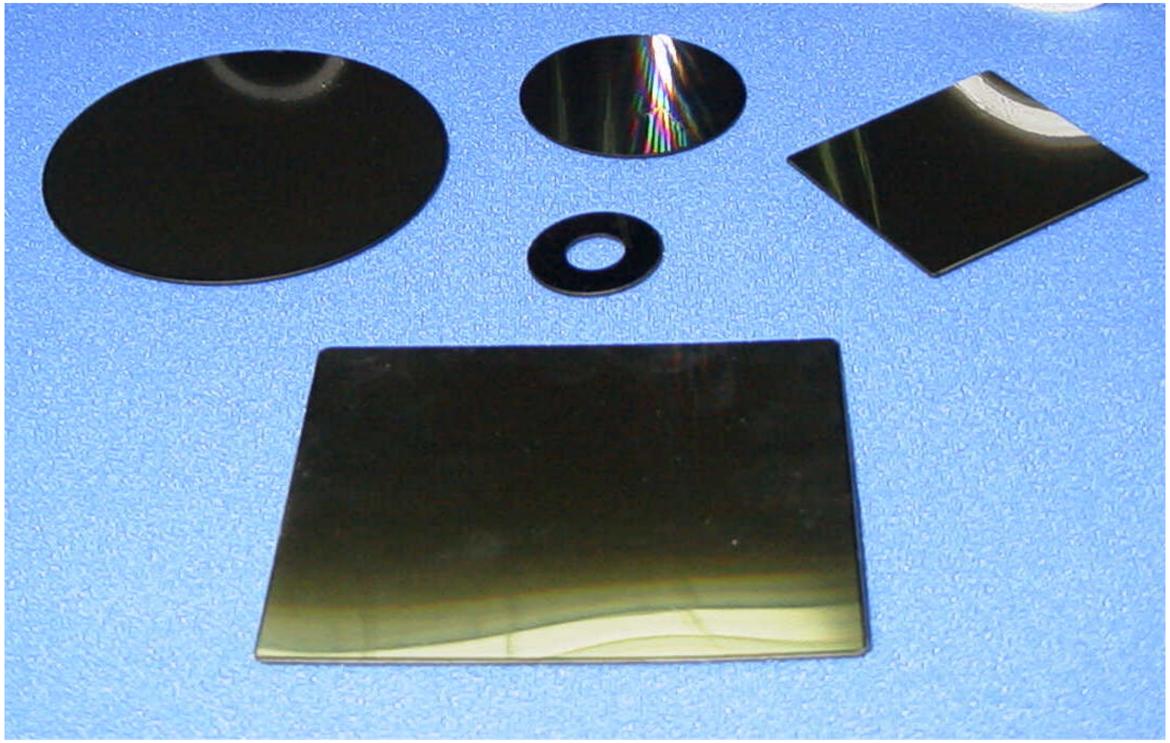
Ion Drift Tube for Ion Mobility Spectrometer



Prototype Resistive Glass Ion Mobility Spectrometer



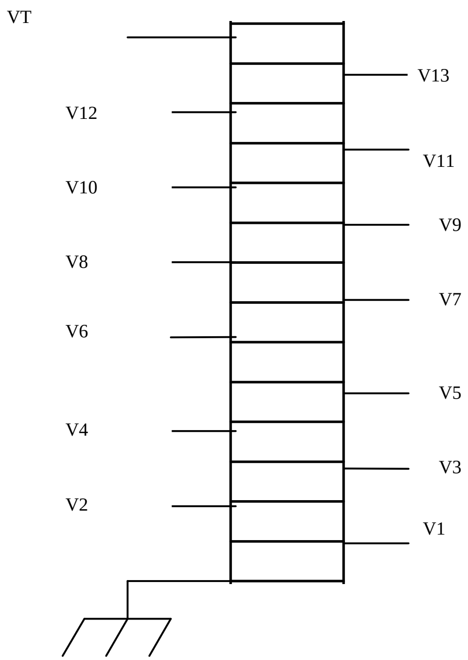
Resistive Glass Plates

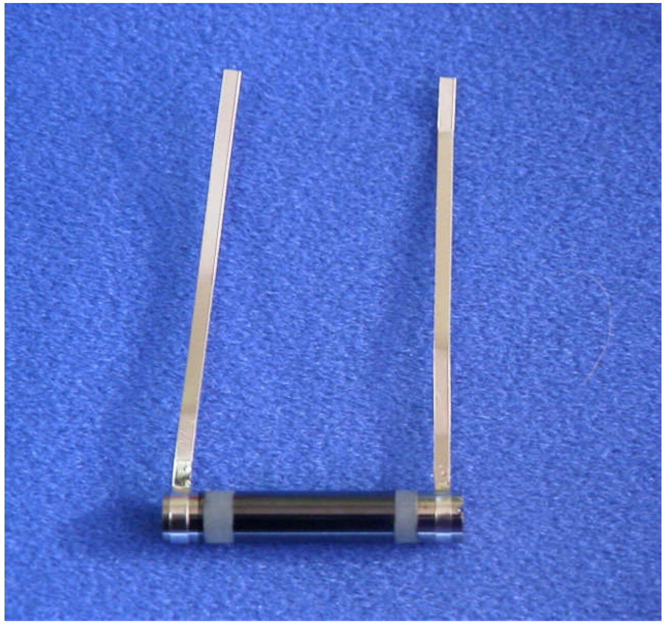


Applications

- •Maldi Targets
- • Voltage dividers
- • Conductive Spacers
- •Orthogonal lens Structures
- •Field Flatteners

Resistive Glass Voltage Divider





Summary

- Resistive glass materials have been developed which have been demonstrated to produce uniform resistive surfaces.
- These materials produce uniform electric fields when voltages are applied which can be used to direct charged particles.
- These materials can be produced in various sizes and shapes and are well suited for use in high vacuum systems.
- The use of resistive glass structures can greatly simplify the construction of ion reflectors, drift tubes and ion guides.