The Development of Novel Resistive Glass Technology to Simplify Ion Reflector Lenses, Ion Guides, Drift Tubes and Ion Source Designs in Analytical Instruments

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Paper 1700-2200 Presented at The 2004 Pittsburgh Conference
March 7, 2004

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.
- New applications for Mass Spectrometers are constantly emerging; however, many potential applications are very cost sensitive.
- Most of the cost of a mass spectrometer is attributed to the cost of components and the labor for their assembly and test.
- Simplifying assembly in these instruments could lead to a significant reduction in manufacturing cost.

Discussion

- A number of new materials and tools (such as modeling software) have been developed in order to facilitate rapid product development and reduced manufacturing cost.
- One example of this is the line Resistive Glass Products from Photonis.

What are Resistive Glass Products?

PHOTONIS Scientific Detectors

- Resistive Glass Products are resistive, geometric glass structures that can be used to create 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.

Resistive Glass Formats

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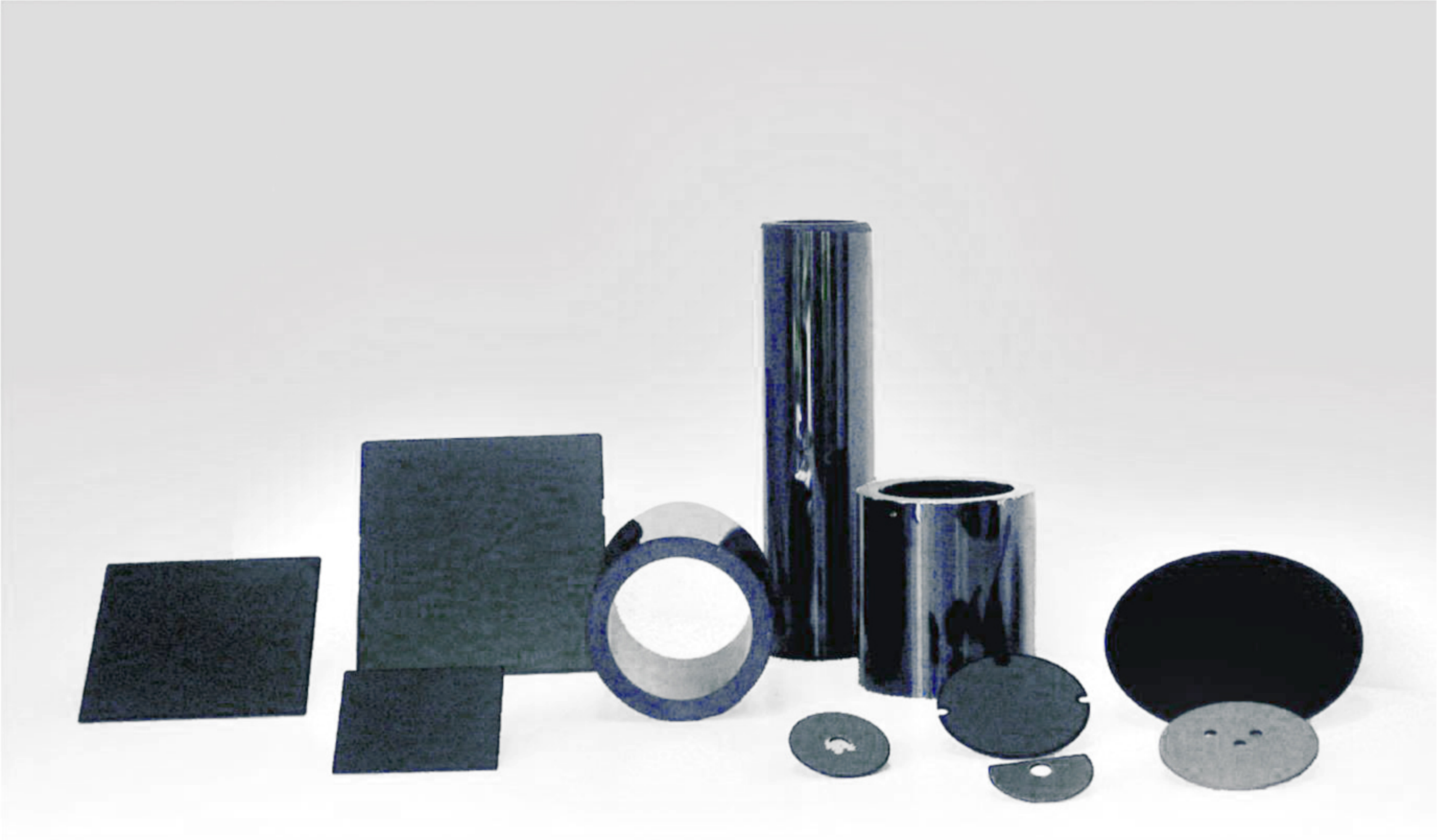

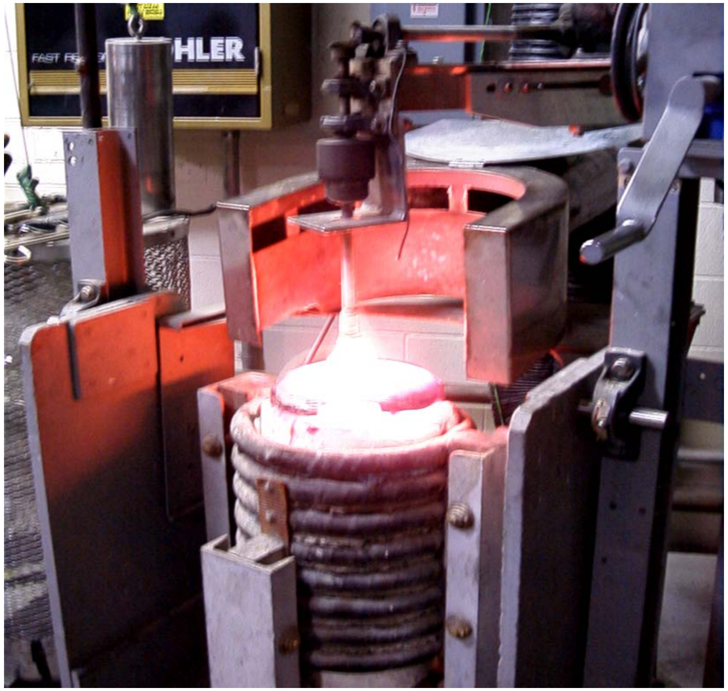

- Resistive Glass Products are made from proprietary glass formulations. They are formed into tubes or flat glass and then heat treated to produce a semi-conductive layer on the surface of the glass.

Manufacturing Steps - Tubing

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Tube Extrusion

Slicing

Milling

Hydrogen Reduction

Metalization

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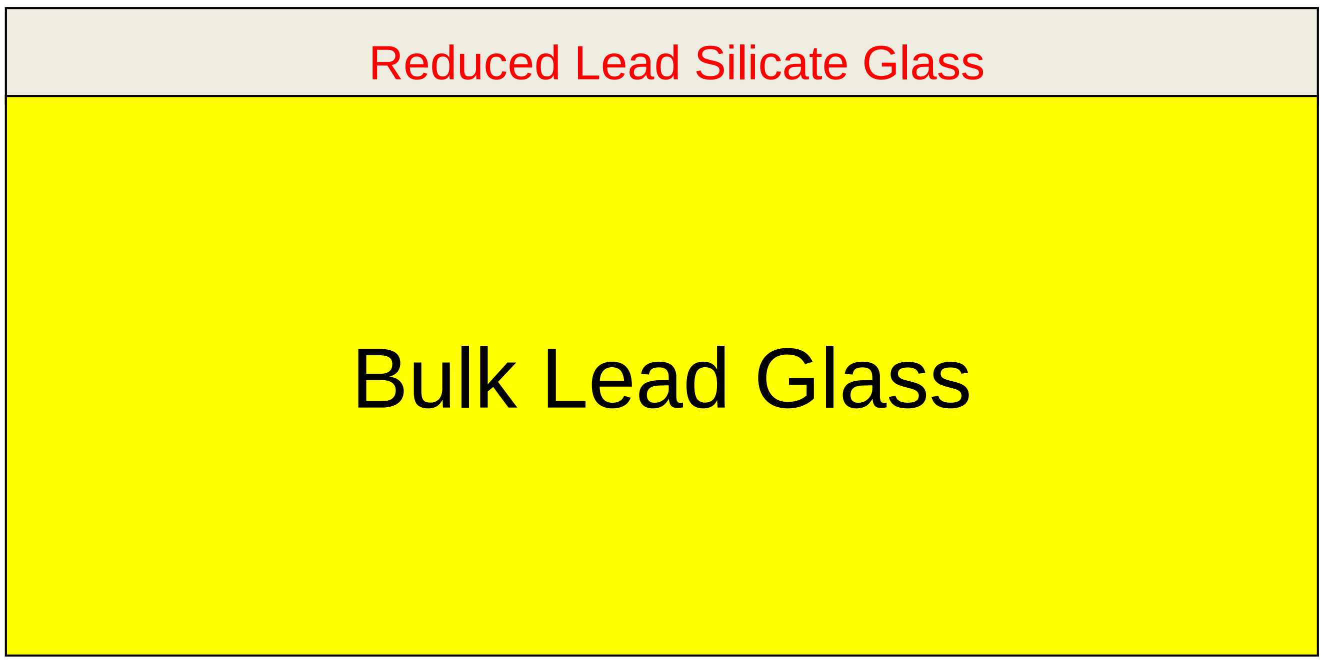
Material Characteristics

Property	Glass Composition 1	Glass Composition 2
Melting Temperature	642^{o}C	613^{o}C
Operating Temperature Range	-20^{o}C to 400^{o}C	-20^{o}C to 400^{o}C
Density	4.44 g/cm^{3}	5.07 g/cm^{3}
Annealing Temperature	480^{o}C	500^{o}C
Temperature Coefficient of Resistivity	~ -1.0%	~ -1.0%
Thermal Expansion Coefficient	76x10^{-7}/ ^{o}C	82x10^{-7} / ^{o}C
Typical Device Resistance Range	10^{8}-10^{11}Ω	10^{5}-10^{11}Ω

Cross Section of Reduced Glass

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



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

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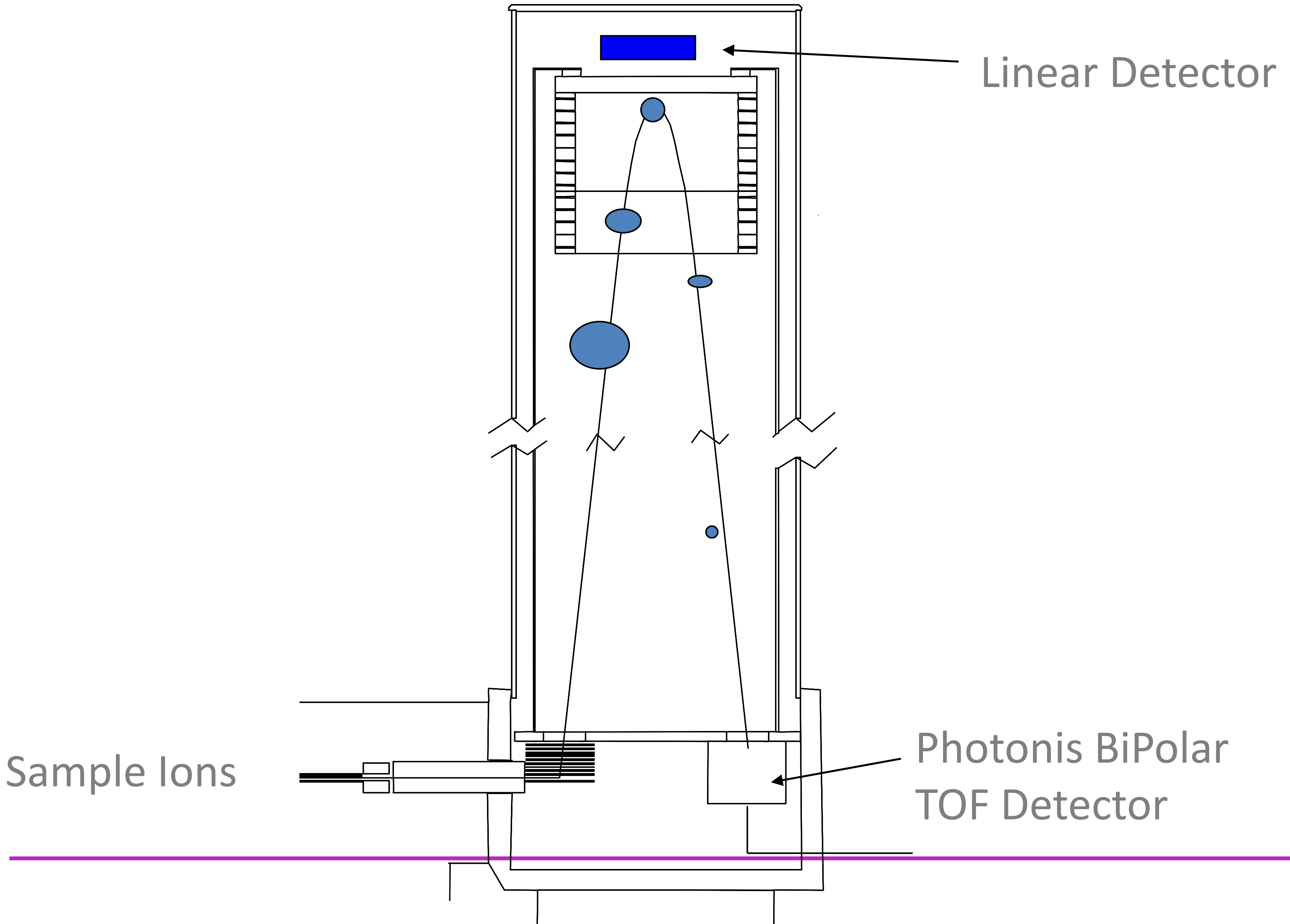
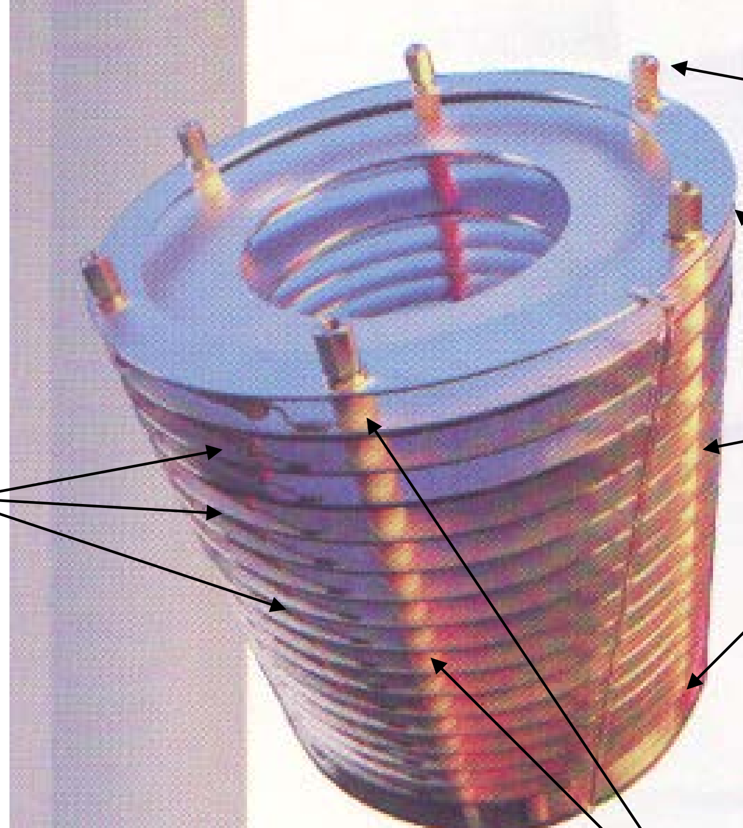


A simple, conventional reflectron lens has ***154 parts***

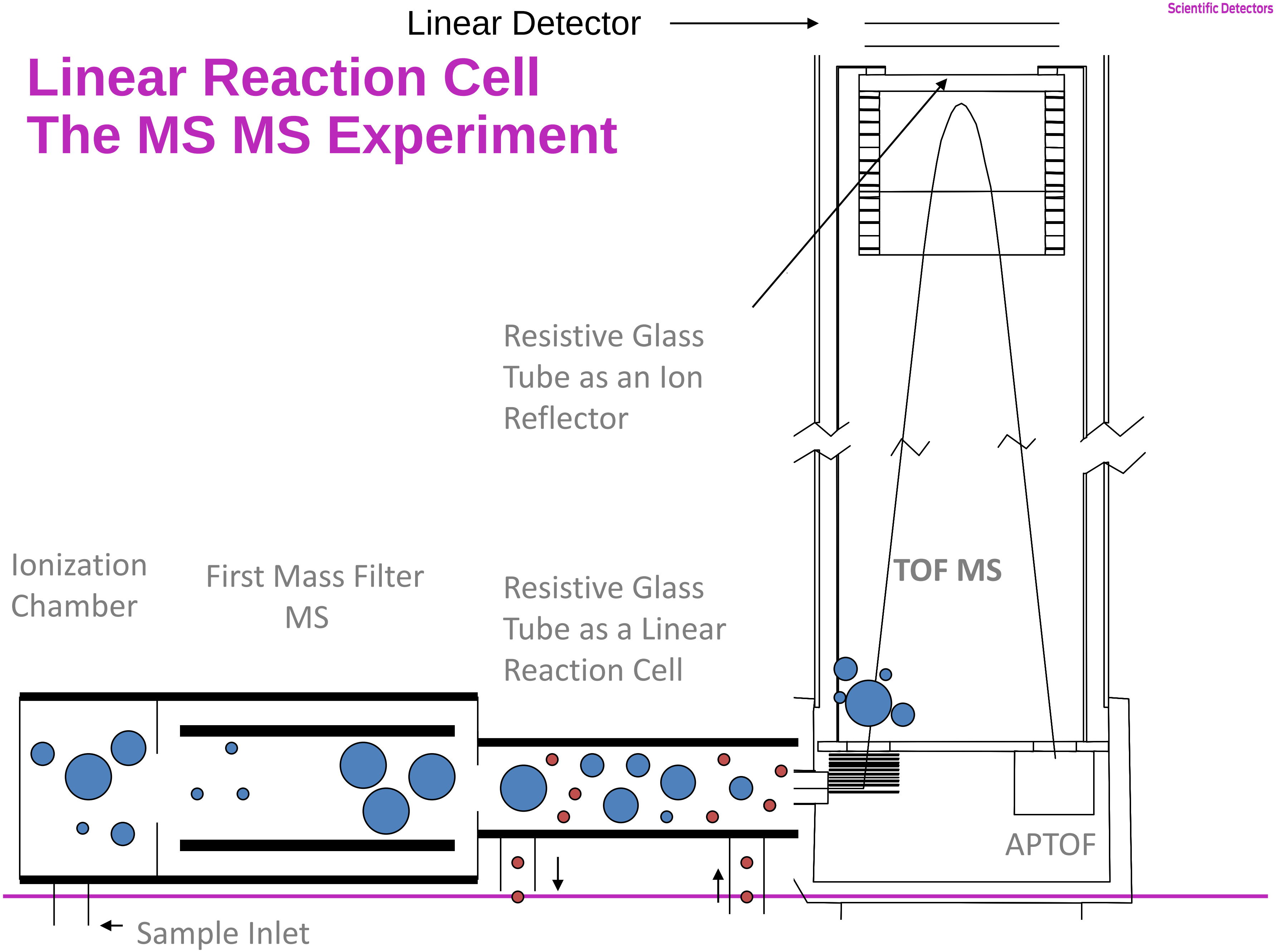


Resistive Glass Reflectron Lens

One Piece
Design

Metalized
Electrode

Linear Reaction Cell
The MS MS Experiment



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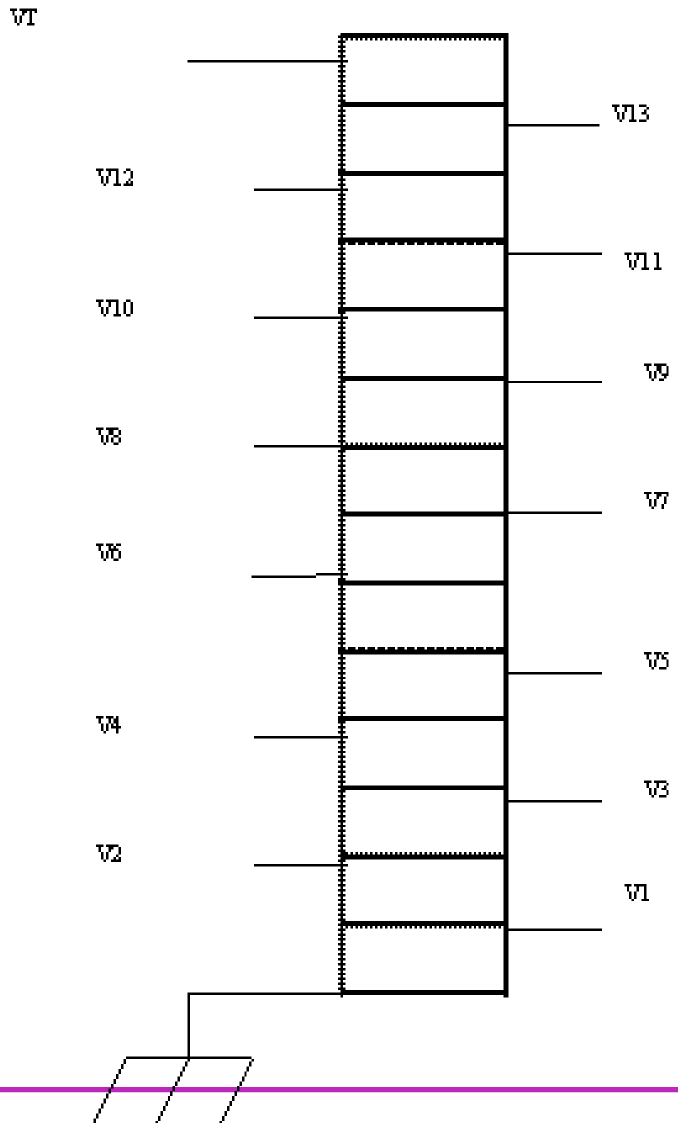
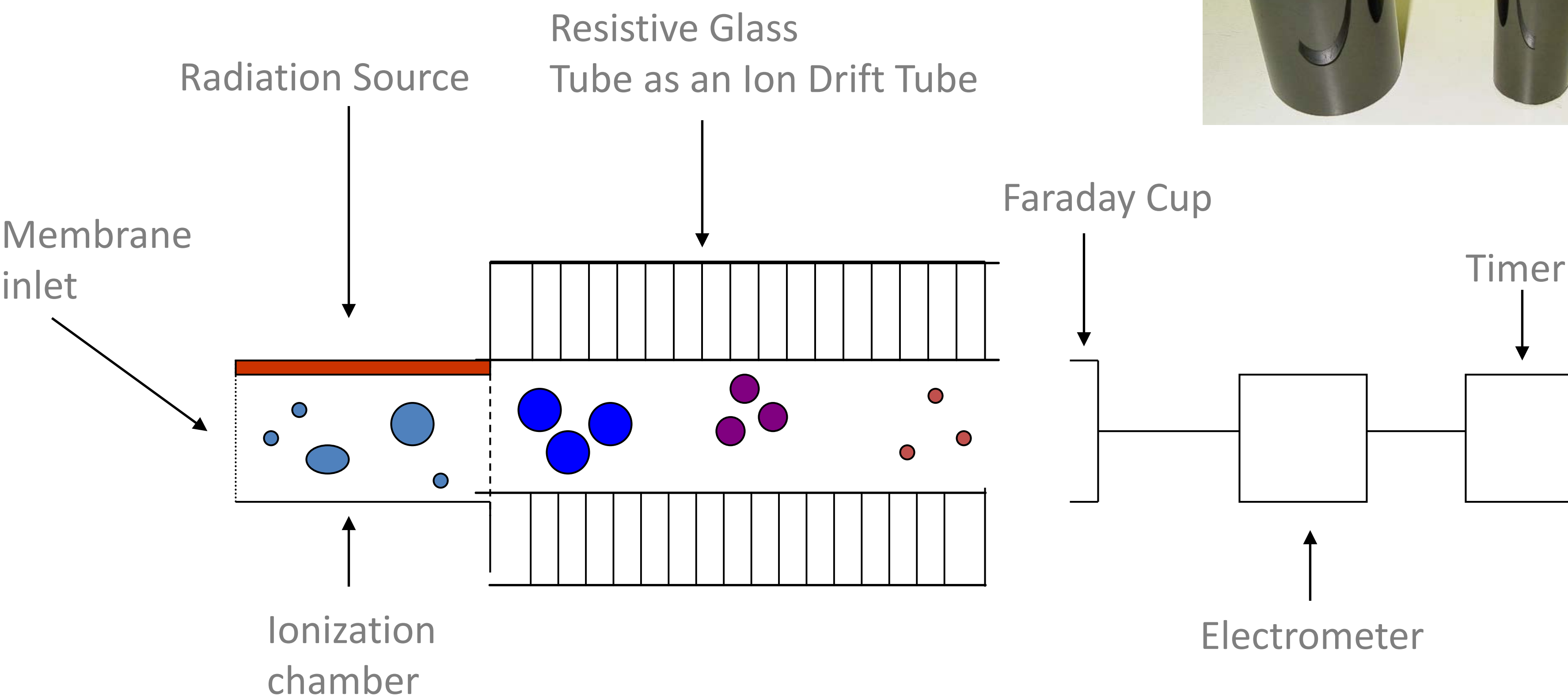
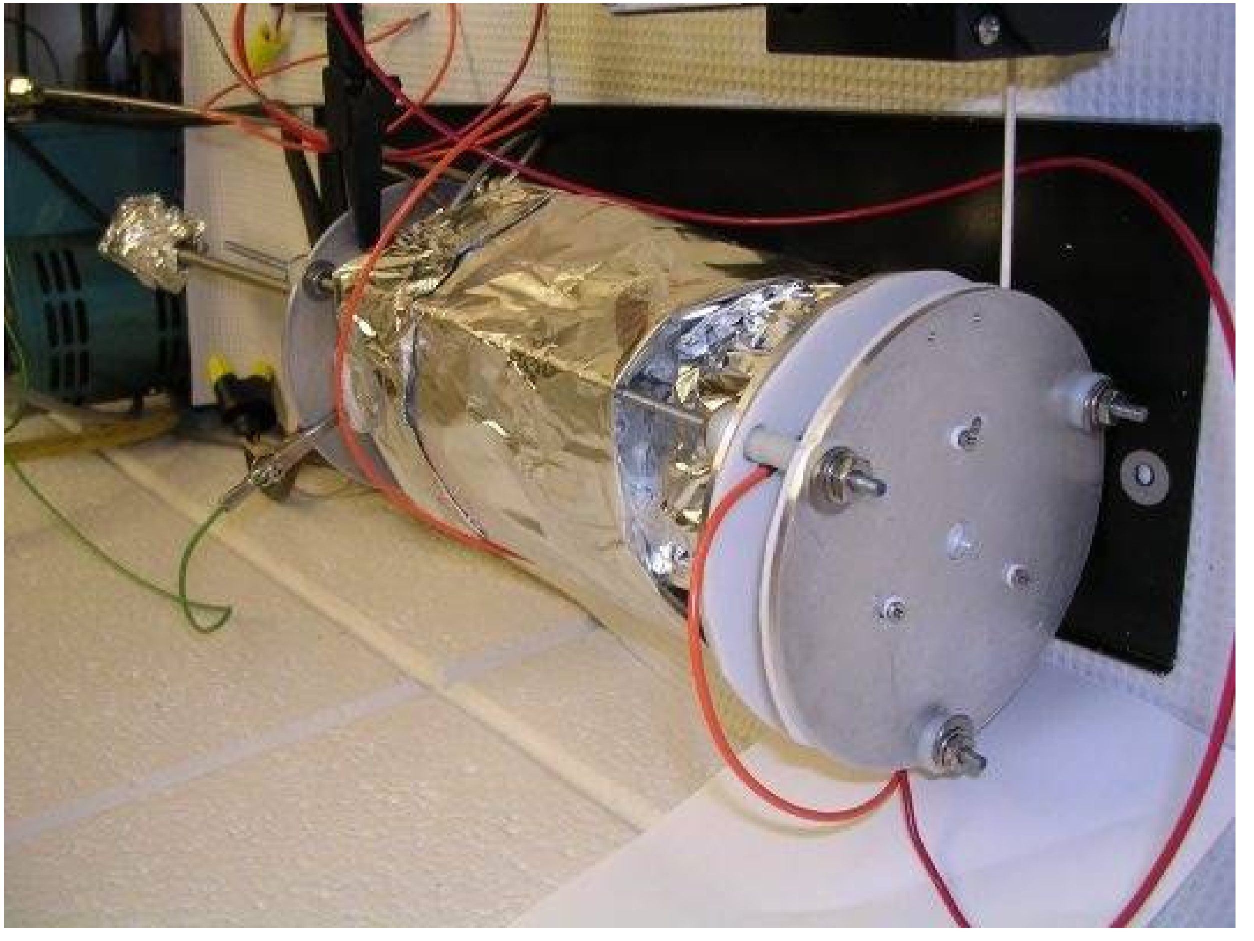
Resistive Glass High Voltage Divider



Ion Drift Tube for Ion Mobility Spectrometer



Ion Drift Tube for Ion Mobility Spectrometer



Based on Resistive Glass Tube Technology – Experiment by N. Liegh, U. of Missouri

Resistance Uniformity Measurement System

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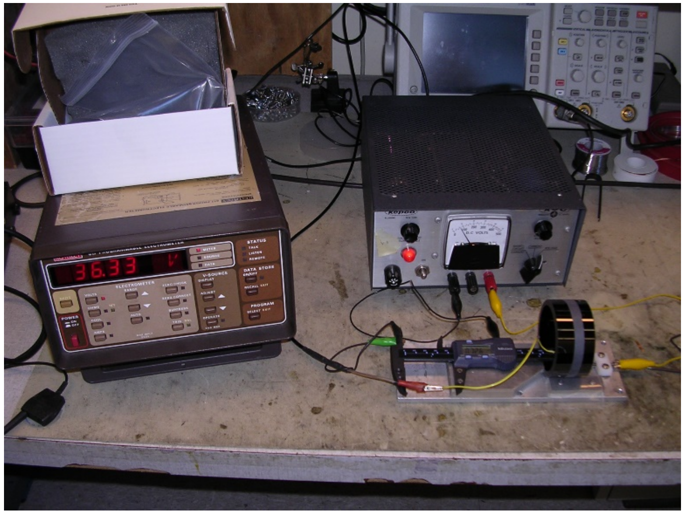
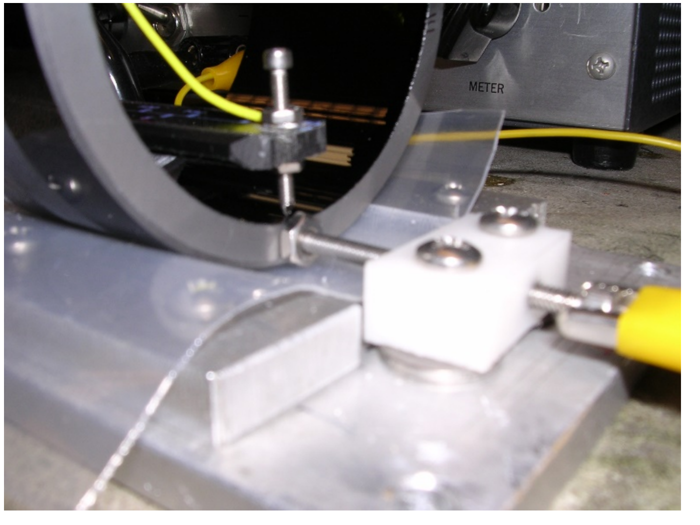
- A DC Voltage was applied across the tube.
- The voltage was measured as a function of distance across length of tube.
- The voltage inside the tube was probed by a sharpened screw attached to the end of the digital caliper slide.
- The voltage was measured by a digital electrometer.
- A linear regression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





Resistance Uniformity Data

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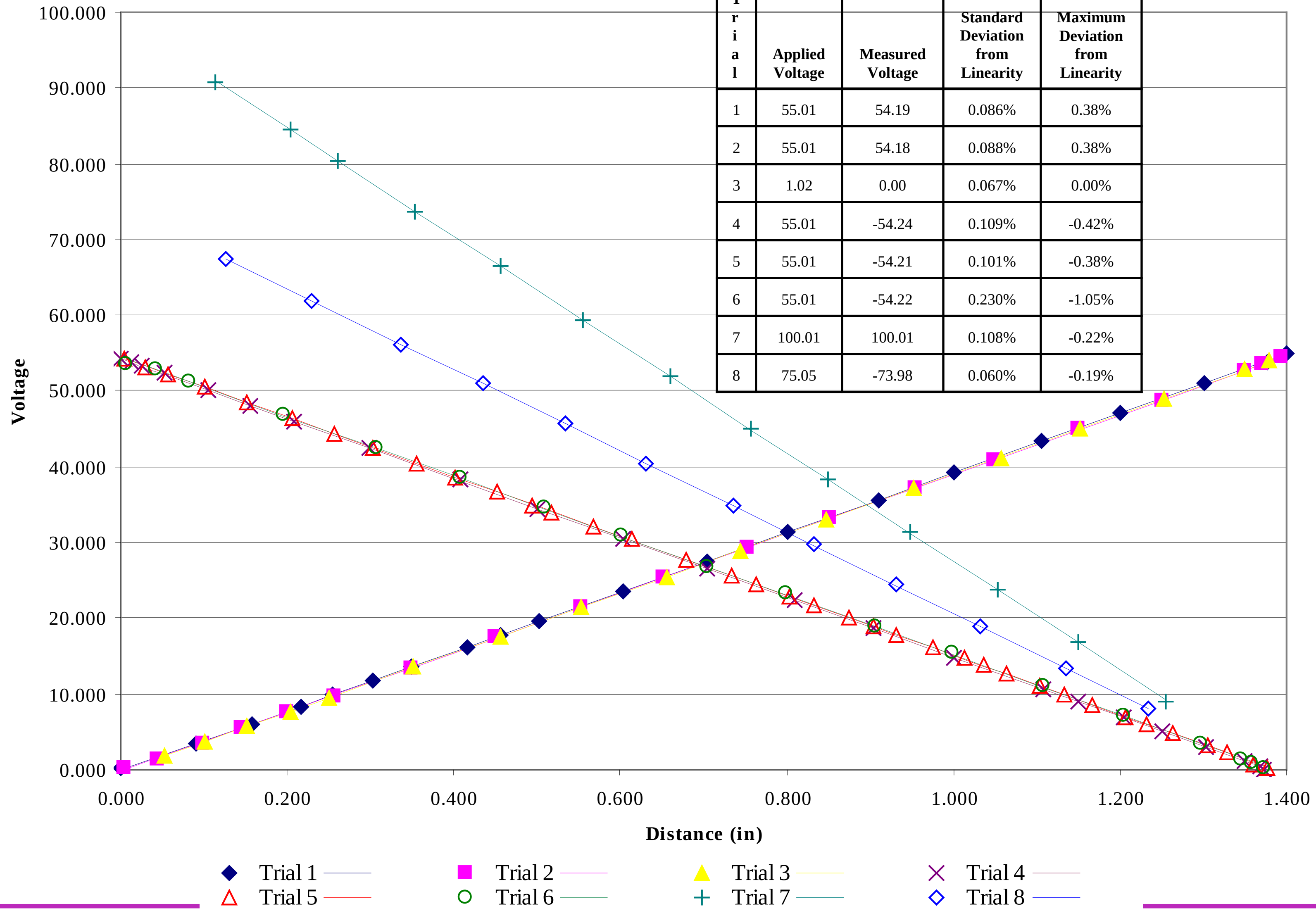
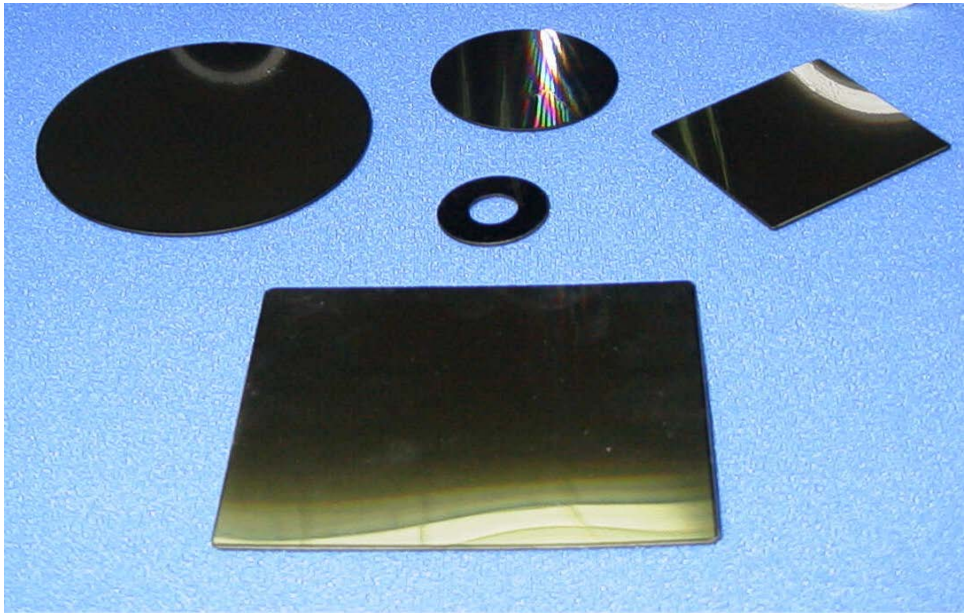


Trial	Applied Voltage	Measured Voltage	Standard Deviation from Linearity	Maximum Deviation from Linearity
1	55.01	54.19	0.086%	0.38%
2	55.01	54.18	0.088%	0.38%
3	1.02	0.00	0.067%	0.00%
4	55.01	-54.24	0.109%	-0.42%
5	55.01	-54.21	0.101%	-0.38%
6	55.01	-54.22	0.230%	-1.05%
7	100.01	100.01	0.108%	-0.22%
8	75.05	-73.98	0.060%	-0.19%

Resistive Glass Plates



Applications

- Maldi Targets
- Voltage Dividers
- Conductive Spacers
- Orthogonal Lens Structure
- Field Flatteners

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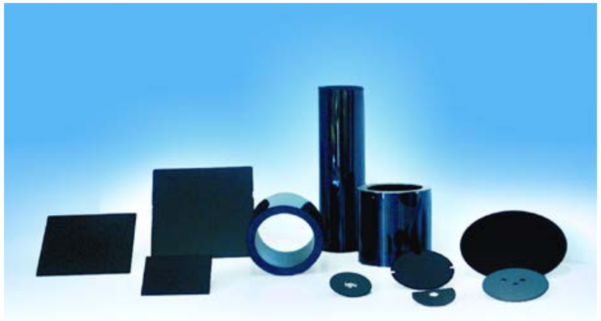
Resistive Glass Products

- **Robust**
- **Single Piece Construction**
- **Nichrome, Copper and Gold Electrodes Available**
- **Wide Variety of Shapes and Sizes: Tubes, Sheets, Washers, Custom Shapes**
- **Uniform Resistance Variable Over 6 Orders of Magnitude***
- **Produce Smooth Electric Fields**
- **Operating Range -20° to 400°C**



BURLE Resistive Glass Products offer a unique capability for analytical instrument designers and manufacturers. These devices are composed of a proprietary lead silicate glass that has been doped to produce a resistive surface. The products can be provided with one or more resistive areas.

The resistivity can be varied over several orders of magnitude in order to optimize current flow and electric field strength. These products are patent pending.

Tube ends are parallel within 0.025mm (.001")
Sheets are flat within 3 fringes
For large (>1mm) ID tubing:
Expansion Coefficient (25–450°C): 78×10^{-7} / °C
Softening Point: 642°C
For 1mm ID tubing:
Expansion Coefficient (25–450°C): 82×10^{-7} / °C
Softening Point: 613°C
Coefficient of Resistivity: -1% per °C
Sheet size up to 102x102mm (4x4")
Resistive washers up to 71mm (2.8") in diameter
Custom shapes available
Mechanical Interfaces: Flanges, Grids and Meshes are available upon request.

**** 1mm ID tubing only***

Typical Mechanical and Electrical Characteristics

Tube Length (Max.)	Inside Diameter (Min.)	Outside Diameter	Wall Thickness	Out of Round (Max.)	Resistance Range
203.2mm 8.000"	57.00mm 2.244"	72.26mm 2.845"	5.84mm 0.230"	1.60mm 0.063"	10^8-10^{11}Ω
203.2mm 8.000"	45.65mm 1.797"	63.50mm 2.500"	7.62mm 0.300"	1.60mm 0.063"	10^8-10^{11}Ω
203.2mm 8.000"	36.83mm 1.450"	47.00mm 1.850"	3.81mm 0.150"	0.74mm 0.029"	10^8-10^{11}Ω
304.8mm 12.000"	29.97mm 1.180"	41.40mm 1.630"	5.33mm 0.210"	0.74mm 0.029"	10^8-10^{11}Ω
304.8mm 12.000"	23.50mm 0.925"	31.75mm 1.250"	3.68mm 0.145"	0.48mm 0.019"	10^8-10^{11}Ω
304.8mm 12.000"	1.00mm 0.039"	6.10mm 0.240"	2.57mm 0.102"	0.076mm 0.003"	10^5-10^{11}Ω
304.8mm 12.000"	1.00mm 0.039"	3.18mm 0.125"	1.02mm 0.040"	0.076mm 0.003"	10^5-10^{11}Ω
304.8mm 12.000"	1.00mm 0.039"	2.06mm 0.081"	0.53mm 0.021"	0.076mm 0.003"	10^5-10^{11}Ω

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.