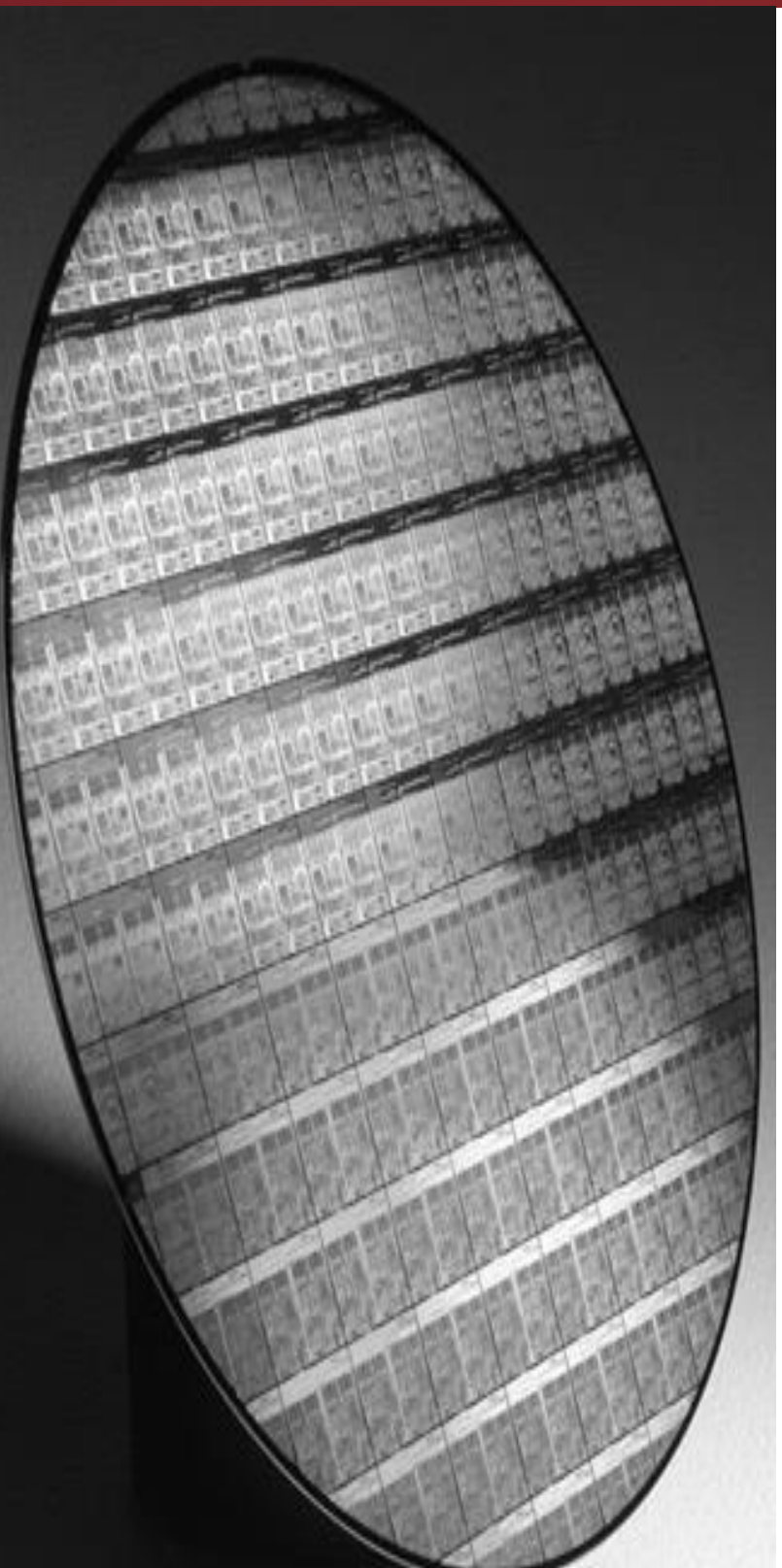
Impedans
PLASMA MEASUREMENT

Semion Pulsed DC RFEA Systems

RETARDING FIELD ENERGY ANALYSERS FOR HIGH-RESOLUTION (44 ns) IEDF MEASUREMENT IN PULSED DC PLASMAS



Semion™ Pulsed DC

Retarding Field Energy Analysers

Compatible Plasma Types

DC, Pulsed DC, RF, Pulsed RF & Microwave

Interchangeable Sensing Elements

Compatible with a wide range to plasma densities and gas pressures.

Semion Pulsed DC RFEA systems

The Semion Pulsed DC system is a precision plasma measurement instrument used to measure the time dependence of the ion energy distribution arriving at any surface in a plasma chamber. The Semion Pulsed DC system is the key instrument used to measure the temporal evolution of the ion energy and flux at different times through the pulse period of a pulsed DC plasma process. It is the only commercial RFEA technology on the market with sub-microsecond time resolution. A variety of replaceable sensing elements with different signal sensitivities are available to probe a wide range of plasma ion current densities.

The Semion pDC system provides 44ns time resolution for pulsed plasmas up to 350 kHz. The Semion Pulsed DC can be placed on a high voltage biased or grounded surface. Among the key parameters measured are Ion Energy, Ion Flux and electrode voltage. The Semion Pulsed DC provides plasma parameter measurement in ion beam applications and in DC, Microwave, Continuous and Pulsed plasma. The Semion Pulsed DC is the only fully automated retarding field energy analyser with submicron time resolution, using replaceable RFEA sensors.

Key Features

- Energy range up to 2000 eV (process dependant) and operating frequency range from DC to 350 kHz.
- Suitable for grounded, floating and Pulsed DC biased conditions.
- Time averaged and time resolved measurements with up to 44 ns time resolution (sensor cable length dependant).
- Fully automated software analysis including IEDF adjustment for sensor DC bias potential.
- Replaceable sensor elements with different sensitivities ranging from 0.001 Am^{-2} to 700 Am^{-2}.
- Sensor elements and holder available in anodised aluminium, bare aluminium or stainless-steel options.
- Can be mounted on a Pulsed DC biased electrode with up to 400 V peak-to-peak applied.

Key Benefits

- Portable system allowing analysis in multiple chambers using a single system.
- Provides in-situ measurement of Ion Energy Distribution (IED) under plasma processing conditions.
- Ideal for characterising Pulsed DC plasma processes (magnetron sputtering, HiPIMS, PLD).
- High pressure Button Probes™ extend the pressure ranging to 1.5 Torr (limited to 150 eV energy range).
- Provides insight for fundamental research and for plasma model validation.
- Generate process data for customer escalations or product marketing.
- Correlate process performance with the key plasma process drivers (ion energy and ion flux).

Low Cost of Ownership

The Semion system was designed to have replaceable, low-cost sensing elements, each with a lifetime ranging from 10s to 100s of hours of plasma exposure. The other system components can be used repeatedly without the need for replacement. The sensor holder assembly is easily installed in (and uninstalled from) the processing chamber, making it convenient to move to other plasma tools as required.

Cost Benefits

Enormous cost benefits can be achieved through the use of the Semion system. Process issues can be identified through direct measurement of the key process drivers in real time. This can be more effective than processing test wafers for offline analysis using costly metrology tools to examine etch or deposition rate uniformity, for example.

Unparalleled Insight

The key process driver in the majority of plasma processes is the ion energy distribution arriving at the substrate. There are many sensors and instruments on the market to measure the various process inputs such as power, pressure, and gas flow. These measurements provide no insight into what happens at the wafer other than from empirical models. There are also a range of instruments that measure parameters related to the bulk plasma conditions such as plasma density and electron temperature. While these are useful to know, a model of the plasma and sheath adjacent to the wafer is required to predict the ion energy and flux at the wafer. Direct measurement of the ion energy distribution at the wafer position provides the deepest process insight. The Semion system is the only instrument on the market that can provide this type of measurement across a broad range of plasma processing conditions.

Smart Design for Ease of Use

While the theory of operation and the fine tuning of electrical potentials to be applied to the grid stack (that make up the sensing elements) can be complicated, the user-friendly design of the Semion system makes it easy to use for all levels of expertise. The grid potential configurations are carried out using smart algorithms based on measured DC bias voltage. After minimal configuration, through the intuitive software user interface, an IEDF scan can be performed and results displayed to the user within seconds.

Model Options

Full Systems Options

Table 1: Semion System product family & availability

System Name	Supply Status	Spare Parts Availability			
		Sensor	Holder	Feedthrough	Controller
Semion 500	Obsolete	✗	✗	✗	✗
Semion 800	Obsolete	✓	✓	✓	✗
Semion 2500	Obsolete	✓	✓	✓	✗
Semion Single[1]	Active	✓	✓	✓	✓
Semion Multi[1]	Active	✓	✓	✓	✓
Semion pDC	Active	✓	✓	✓	✓
Semion 3kV[1]	Active	✓	✓	✓	✓

Control Unit Options

Table 2: Semion System – Controller Options

Part #	Product Name	Max. Scan Voltage Range[2]
02-0549-01	Semion pDC | Electronics Unit	± 2000V DC

[1] Have separate data sheets.
[2] Actual ion energy scan range is determined by systems components.

Feedthrough Options

Table 3: Semion System – Feedthrough Module Options

Part #	Product Name	Max. DC Withstanding Voltage
02-0547-01	Semion pDC | Feedthrough	± 2000V

Sensor Holder Options

Table 4: Semion pDC System – Single Sensor Holder Options[3,4]

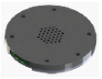
Part #	Product Name	Material
02-0528-01	Single Holder | pDC | Ø50 mm	Anodized Aluminium
02-0529-01	Single Holder | pDC | Ø50 mm	Aluminium
02-0530-01	Single Holder | pDC | Ø50 mm	Stainless Steel
02-0017-01	Single Holder | pDC | Ø70 mm	Anodized Aluminium
02-0593-01	Single Holder | pDC | Ø70 mm	Aluminium
02-0594-01	Single Holder | pDC | Ø70 mm	Stainless Steel
02-0531-01	Single Holder | pDC | Ø100 mm	Anodized Aluminium
02-0532-01	Single Holder | pDC | Ø100 mm	Aluminium
02-0533-01	Single Holder | pDC | Ø100 mm	Stainless Steel
02-0534-01	Single Holder | pDC | Ø150 mm	Anodized Aluminium
02-0535-01	Single Holder | pDC | Ø150 mm	Aluminium
02-0536-01	Single Holder | pDC | Ø150 mm	Stainless Steel
02-0537-01	Single Holder | pDC | Ø200 mm	Anodized Aluminium
02-0538-01	Single Holder | pDC | Ø200 mm	Aluminium
02-0539-01	Single Holder | pDC | Ø200 mm	Stainless Steel
02-0540-01	Single Holder | pDC | Ø300 mm	Anodized Aluminium
02-0541-01	Single Holder | pDC | Ø300 mm	Aluminium
02-0542-01	Single Holder | pDC | Ø300 mm	Stainless Steel

[3] The Semion pDC single sensor holders have a rated withstanding voltage of 2000V DC.
[4] The Semion pDC single sensor holder has a ceramic-bead covered cable terminated with 2 HV-BNC connectors. Cable length to be specified at time or order.

Button Probe™ Sensing Element Options

Table 54: Semion pDC – Button Probe Sensing Element Options[5]

Part #	Product Name
02-0339-01	Button Probe | Semion pDC | Anodized Aluminium | Standard Density
02-0342-01	Button Probe | Semion pDC | Anodized Aluminium | Low Density
02-0345-01	Button Probe | Semion pDC | Anodized Aluminium | High Density
02-0340-01	Button Probe | Semion pDC | Aluminium | Standard Density
02-0343-01	Button Probe | Semion pDC | Aluminium | Low Density
02-0346-01	Button Probe | Semion pDC | Aluminium | High Density
02-0341-01	Button Probe | Semion pDC | Stainless-Steel | Standard Density
02-0344-01	Button Probe | Semion pDC | Stainless-Steel | Low Density
02-0347-01	Button Probe | Semion pDC | Stainless-Steel | High Density
02-0595-01	Button Probe | Semion pDC | Anodised Aluminium |High Pressure Std Density
02-0598-01	Button Probe | Semion pDC | Anodised Aluminium | High Pressure Low Density
02-0601-01	Button Probe | Semion pDC | Anodised Aluminium | High Pressure High Density
02-0596-01	Button Probe | Semion pDC | Aluminium | High Pressure Std Density
02-0599-01	Button Probe | Semion pDC | Aluminium | High Pressure Low Density
02-0602-01	Button Probe | Semion pDC | Aluminium | High Pressure High Density
02-0597-01	Button Probe | Semion pDC | Stainless-Steel | High Pressure Std Density
02-0600-01	Button Probe | Semion pDC | Stainless-Steel | High Pressure Low Density
02-0603-01	Button Probe | Semion pDC | Stainless-Steel | High Pressure High Density



Parameters Reports

Table 5: Parameters Reported by Semion pDC System.

Parameters measured by the Semion pDC	
Parameters Displayed	**Description**
Semion pDC	
IV Curve [Time Averaged | Time Resolved]	Current v. Voltage Curve
IEDF [Time Averaged | Time Resolved]	Ion Energy Distribution Function
J_i [Time Averaged | Time Resolved]	Ion Flux

[5] Operating pressure ≤ 300 mTorr. High pressure Buttons extend range to 1.5 Torr but limit voltage range to 150 V.

Specifications

Controller Specifications

Table 76: General Controller Specifications

Controller Environmental Specifications	
Mains voltage	100 – 240 V AC
Mains Current	1.6 A AC
Mains frequency	47 – 63 Hz
Installation category	II
Pollution degree	1
Max. relative humidity	95%, non-condensing
Max. operating temperature	55^0 C
Max. altitude	3000 meters
Protection rating	IP20 (IEC 60529)

Table 8: Semion pDC Controller Specifications

Controller Operating Specifications	
# Voltage Channels	3 (G1/G2/C)[6]
Voltage Scan Range	-2000 V to +2000 V per channel
Current Range	±1 mA per channel
Connectivity	USB 2.0
PC Operating System	Windows XP / 7 / 8 / 10
Sampling Rate	22 MS/s
Data Acquisition Resolution	$16\ bit$
Time Resolved Step Resolution	44 ns
External Sync (for time resolved mode)	TTL
Synchronization frequency range	4 Hz to 350 KHz
Electrical Connections	3x HV BNC connectors

[6] Semion pDC is designed to work with a three grid retarding field analyser only.

Feedthrough Module Specifications

Table 9: Semion pDC Feedthrough Module Specifications

Feedthrough Module Specifications	
# Voltage I/O Channels (Airside)	3 input (G1/G2/C), 1 output (G0)
DC Withstanding Voltage	3000 V for each channel
Max. Current[27]	±60 µA per channel
Electrical Connections (Airside)	3x HV BNC connectors
Connectivity	HV cables to controller, Ethernet cables to controller
Sensor DC Voltage Measurement	Requires voltmeter connected to G0 port
Vacuum Flange Options	KF40 (Custom adapters available)
Vacuum Side Interface	2x Floating Shield SHV connectors
Frequency Range	1 kHz – 350 kHz
Max. pDC Bias Voltage (Applied to Sensor)	400 V peak-to-peak
Time Resolution	44 ns

Sensor Holder Specifications

Table 7: Semion pDC – Single Sensor Holder Specifications

Single Sensor Holder Specifications	
Holder Diameter	50/70/100/150/200/300 mm
Holder Thickness	5 mm
Holder Material	Aluminium/Anodized Aluminium/Stainless Steel
Protective Cable Shielding	Ceramic fish-spine beading
Cable OD	7 mm
Cable Length	650 mm standard, customizable to several meters
Cable Bend Radius	30 mm
Cable Plug	2x SHV male connectors
Button Probe Receiver Pocket OD	33 mm
Button Probe Fixings	2x M2x5 mm countersunk screws
Max. operating temperature	150^0 C

Button Probe – Sensing Element Specifications

Table 11: Semion pDC – Button Probe Specifications

Sensing Element Specifications	
Button Probe Diameter	33 mm
Button Probes Thickness	3.2 mm
Button Probe Material	Aluminium/Anodized Aluminium/Stainless Steel
# Sensing Apertures	1/7/37 [low/high/standard density respectively]
Aperture Diameter	10/0.5/0.8 mm [low/high/standard density respectively]
# Grids	3 (G0/G1/G2) & 1 Collector
Grid Hole Size	25 x 25 microns (square holes)
Grid Transparency	54% (High/Standard density), 70% (Low density)
Pressure Range Options	≤ 300 mTorr (≤ 800 eV) & ≤ 1.5 Torr (≤ 150 eV)
Ion Flux Conversion Factors	3.71e4/4.62e6/3.41e5 [low/high/standard density respectively]
Button Probe Fixings	2x M2 threaded screw holes

Sensing Element Specifications	
Max. operating temperature	150^0 C
DC Withstanding Voltage	1000 V (≤ 300 mTorr), 150 V (≤ 1.5 Torr)

Dimensional Drawings

Semion Controller

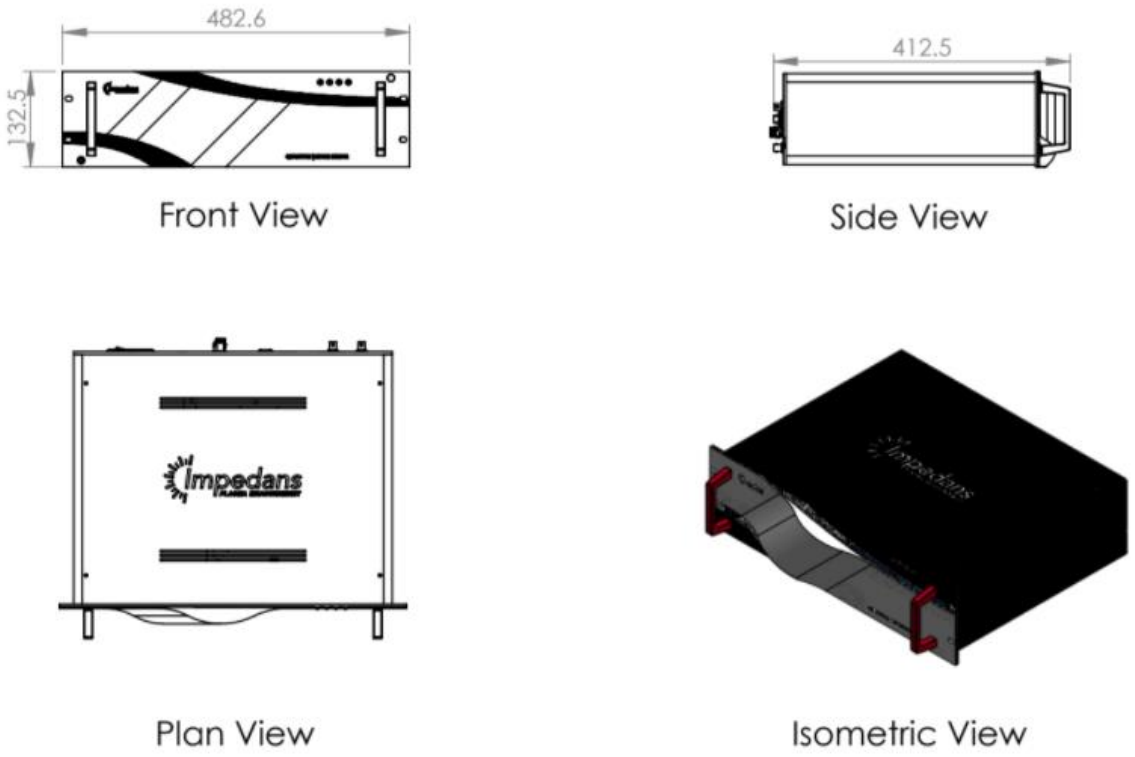


Figure 1: Dimensional drawings of the Semion controller. All dimensions are in mm. Form factor and outer dimensions are the same for all Semion controller models.

Semion Feedthrough | 17 Pin Models

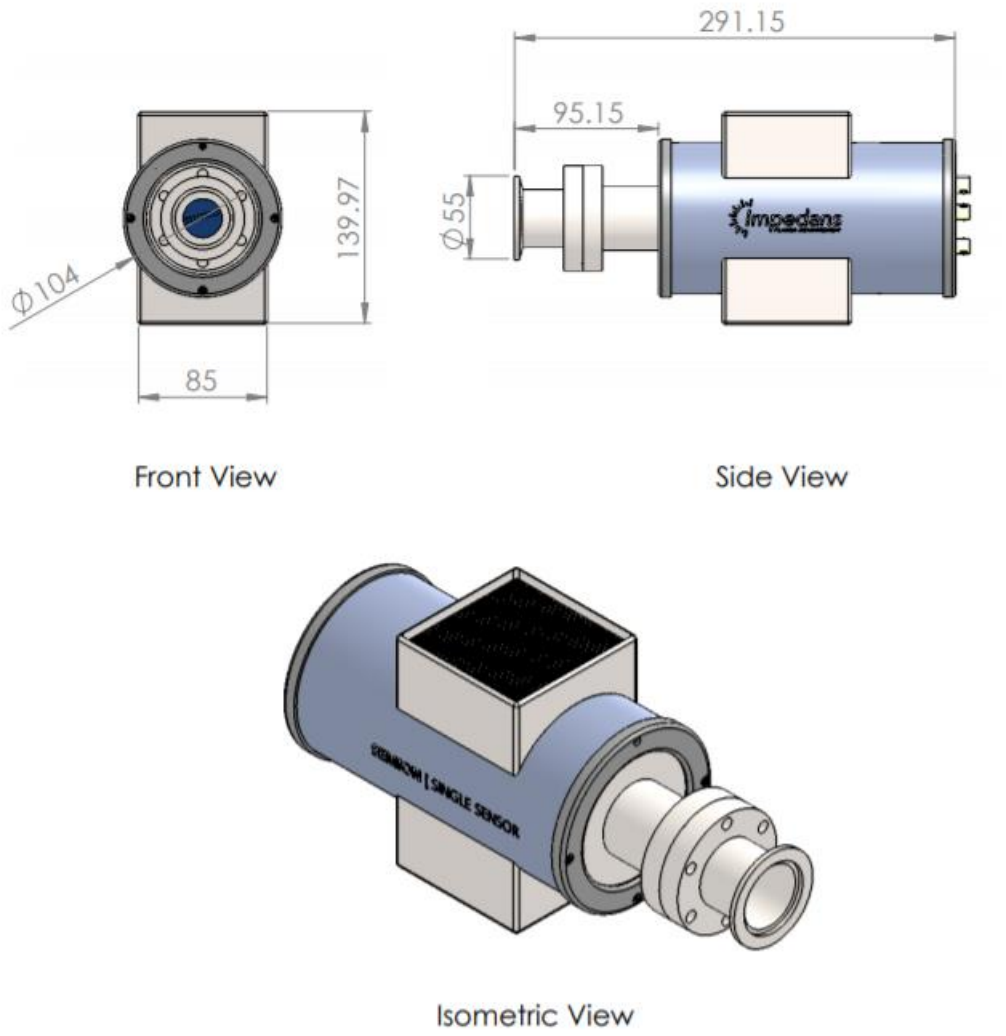


Figure 2: Dimensional drawings of the Semion feedthrough, 17 pin model. It shows an optional CF-to-KF adapter. All dimensions are in mm. Form factor and outer dimensions are the same for all Semion feedthrough models, except the 4 & 5 pin versions.

Semion Single Sensor Holders | 17 Pin Models

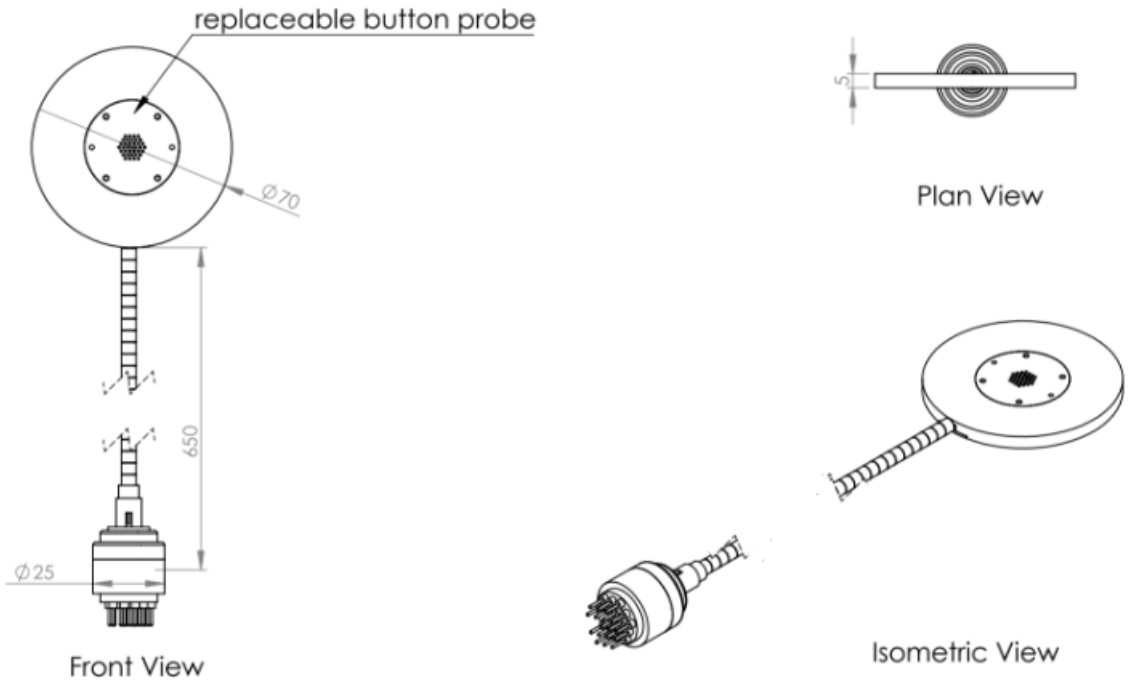


Figure 3: Dimensional drawings of a 70 mm diameter Semion Single sensor holder with 17 pin plug. All dimensions are in mm. The cable length cab be specified at the time of order. Drawing for other models available on request.

Semion Multi Sensor Holders

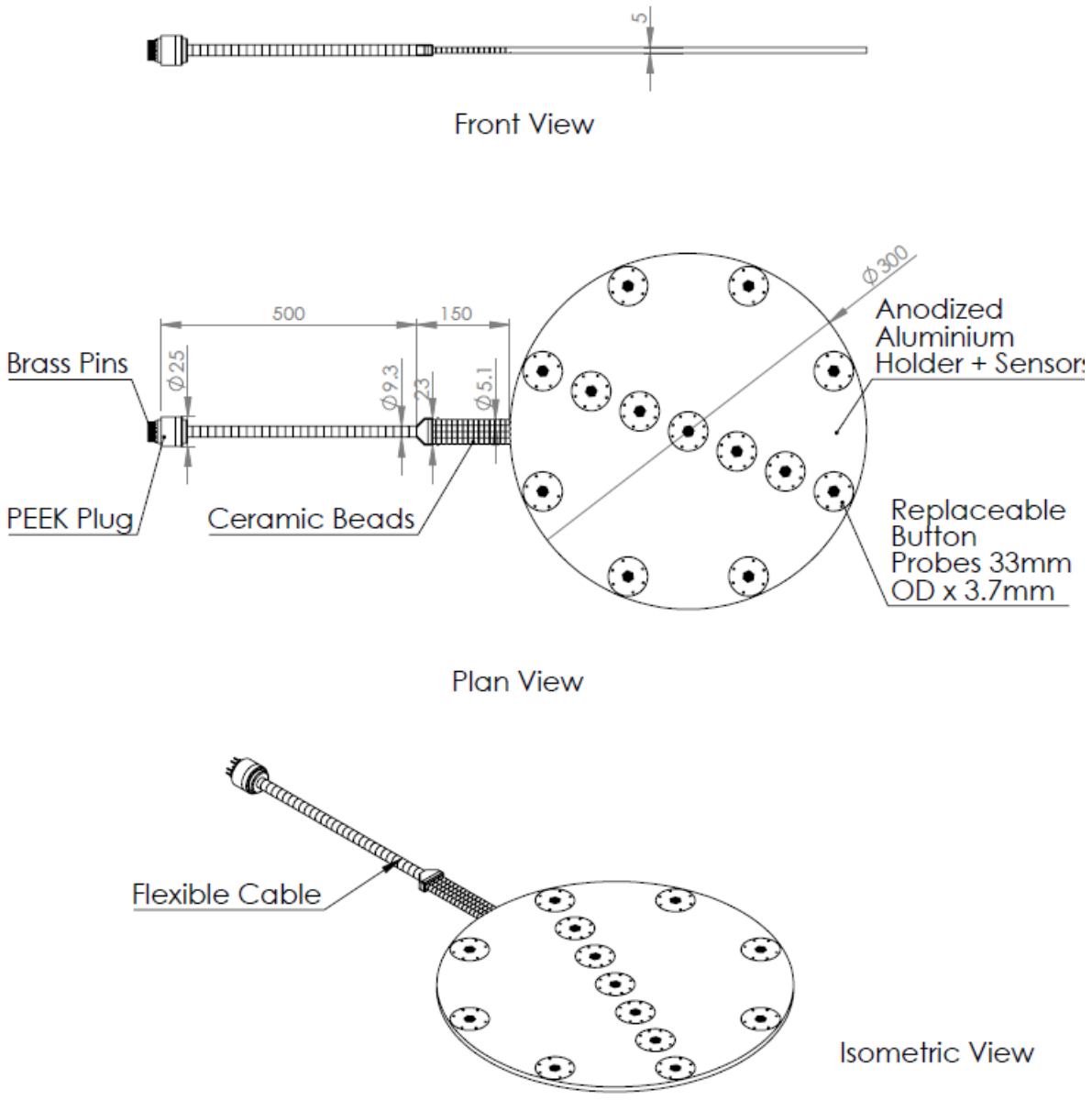
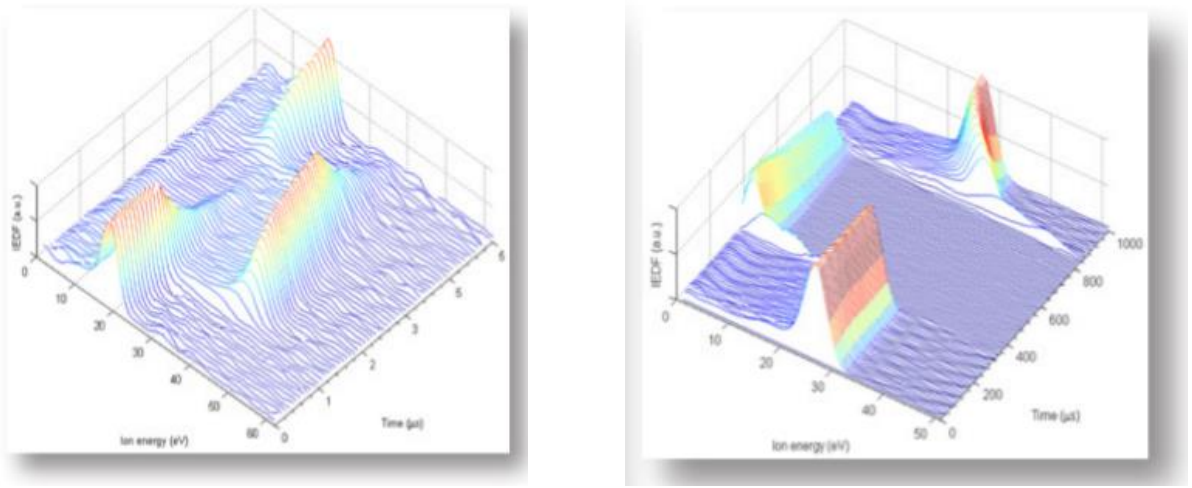
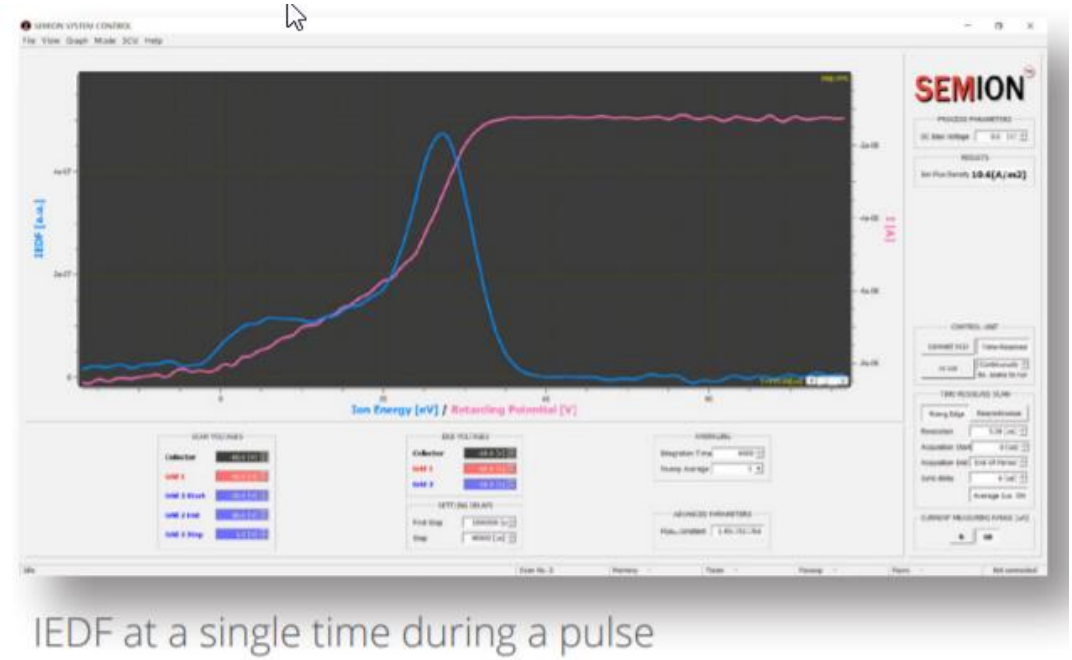


Figure 4: Dimensional drawings of a 300 mm diameter, 13 sensor, Semion Multi holder with 17 pin plug. All dimensions are in mm. The cable length cab be specified at the time of order. Drawing for other models available on request.

Software Screenshots



IEDF vs time through a 200kHz and 1kHz pulse cycle



IEDF at a single time during a pulse