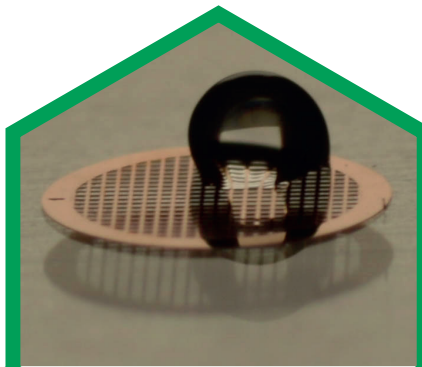
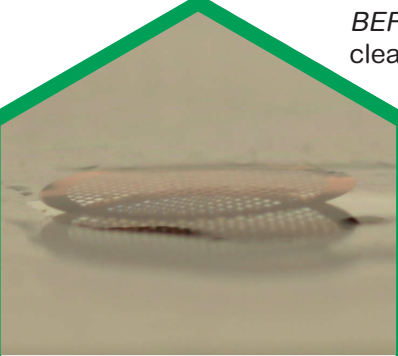


Introducing the

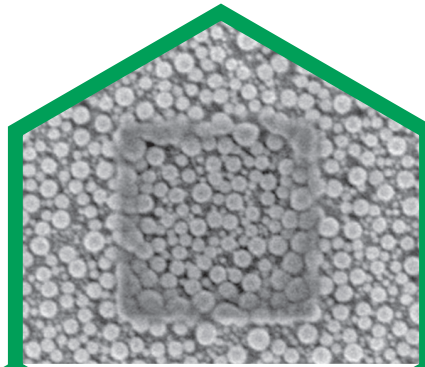
# **Tergeo-EM Plasma Cleaner**



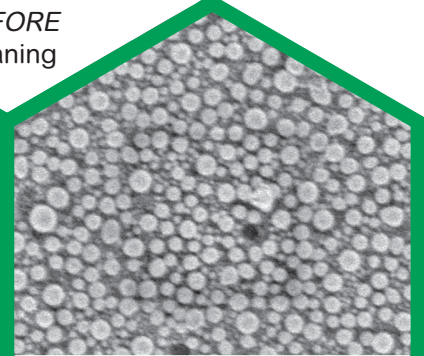
*BEFORE* hydrophilic  
conversion



*AFTER* hydrophilic  
conversion



*BEFORE*  
cleaning



*AFTER*  
cleaning



# Intelligent, versatile plasma cleaning for electron microscopy

PIE Scientific Tergeo-EM is an advanced yet easy to use RF plasma cleaning system for TEM, SEM and FIB applications.

## Key advantages

- **Intuitive touchscreen operation** – quick selection and running of recipes
- **Direct and indirect plasma modes** – process exactly matched to application
- **Pulsed plasma and adjustable power output** – optimal process control
- **Unique plasma sensing** – unsurpassed control of the plasma process
- **Precise sensing of pressure and gas flow** – optimal process control
- **TEM rod adaptors** – for cleaning two TEM rod holders in-vacuo
- **Unique TEM grid holder** – efficient and reliable hydrophilic conversion of carbon support films
- **Adaptable design** – for cleaning, plasma etching, ashing and surface modification

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Tergeo-EM's unique design includes dual RF plasma sources for both immersion (direct) and downstream (indirect) plasma cleaning modes in one instrument. This gives a truly versatile instrument for EM laboratory plasma cleaning and surface modification recipes. The large capacity quartz chamber can be used for bulk cleaning of large objects, such as cryo-TEM autoloader cassettes, along with adaptors for cleaning two TEM rod holders (from all major TEM manufacturers).

Tergeo-EM is also ideally suited for controlled and reproducible hydrophobic/hydrophilic conversion of carbon coated TEM grids and other surfaces with argon, oxygen, hydrogen or simply using ambient air.

Tergeo-EM takes the guesswork out of plasma cleaning. The plasma sensor tells the user the exact plasma strength. The quantitative plasma intensity measurement data is fed back to adjust the gas flow rate and RF power for the desired cleaning speed. You do not need to be a plasma expert to set up correct cleaning recipes for different samples.

For delicate samples pulsed mode operation can reliably generate an extremely weak plasma with an average power of less than 0.25W.

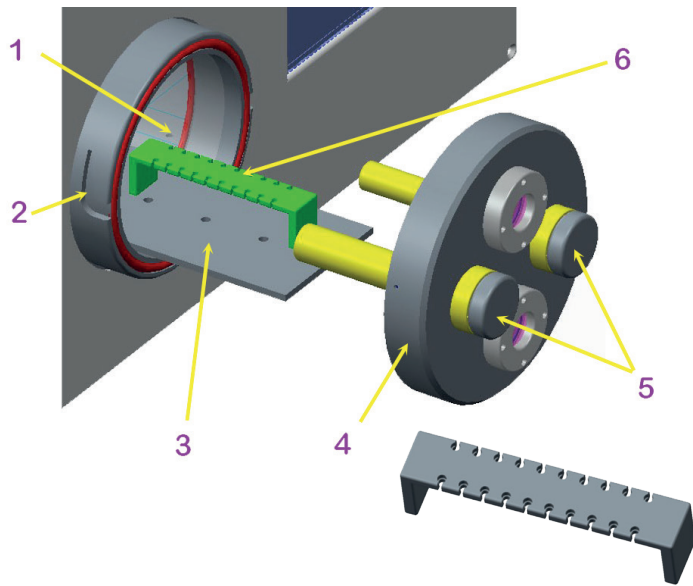
### MODE 1. Rapid, direct immersion mode cleaning

Tergeo-EM direct mode can be used at adjustable power settings for high-speed plasma cleaning applications, such as heavily contaminated SEM and TEM specimens and holders. At reduced power in pulsed mode, it is ideal for applications such as PDMS – glass bonding.

### MODE 2. Gentle, downstream plasma cleaning

In downstream mode Tergeo-EM generates a remote plasma in a separate chamber, optimised for the gentle treatment of delicate samples and TEM grids, without the need for additional shielding. Controlled pulsed plasma is ideally suited for holey, lacey and carbon support films. This significantly reduces specimen heating and eliminates direct ion bombardment, providing superior control and reproducibility. Older style plasma cleaners and glow discharge systems can produce localised hotspots and sparking.

## Tergeo-EM in detail



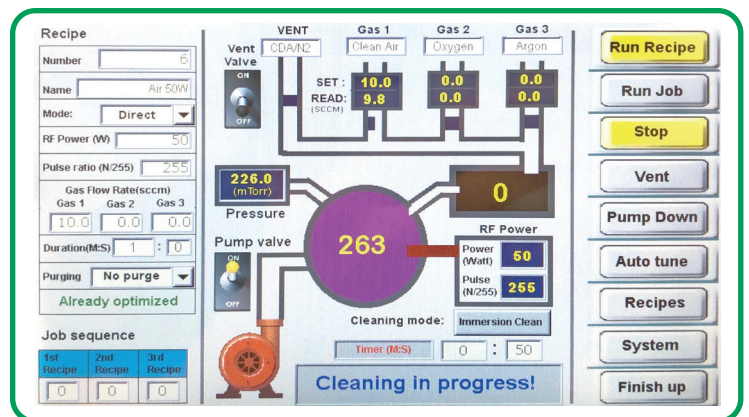
1. Large quartz specimen chamber. ID: 110mm, D: 280mm
2. Front door locking groove. The door is firmly locked onto the chamber during normal operation
3. Quartz specimen shelf with holes for SEM pin stubs
4. Front door is easily removed to provide access to the large specimen chamber
5. Two TEM specimen rods can be cleaned at once – simply remove caps and insert the TEM rods
6. TEM grid holder option

The optional grid holder is used to clean 20 TEM grids per holder. Up to five holders can be placed directly on the quartz shelf, meaning up to 100 grids can be processed at one time.

At the heart of Tergeo-EM is a microprocessor which monitors and controls critical parameters such as pressure, plasma strength and gas flow. An intuitive touch screen interface makes operation as easy as a tablet device. At all time the precise status of the instrument is displayed.

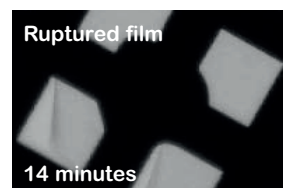
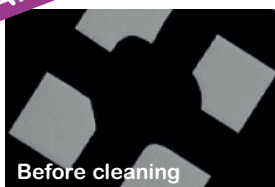
### User interface

The graphical user interface is conveniently divided into three sections. On the left the user can immediately see the parameters of the current recipe. The middle section shows the status of the instrument including gas flow, plasma intensity and runtime. On the right, all actions are easily selectable including run recipe and other settings.



### APPLICATION

## Rendering 3nm ultrathin carbon



Using downstream cleaning mode and pulsed plasma, Tergeo-EM will gently clean fragile ultrathin carbon coated films in less than 2 minutes. Carbon films rupture in some areas after 8 minutes plasma cleaning. After 14 minutes rupture occurs in the central area.



### Plasma sensing technology

A key advantage of Tergeo-EM is its integrated, patent-pending RF plasma sensing technology. Plasma strength is measured and displayed in real time. An algorithm adjusts the plasma strength to optimise plasma ignition and adjust gas flow rates and RF power to give desired cleaning performance. Low-duty cycle pulsed mode operation significantly reduces the average plasma intensity for delicate samples. The user can adjust plasma intensity by changing RF power wattage and/or the RF pulsing duty cycle.

### Gentle, downstream mode

For plasma treatment of TEM grids, gentle downstream processing mode is essential. Plasma generation takes place inside a remote chamber allowing it to diffuse into the main chamber and surround the grid holder(s). In downstream mode only neutral, lower energy radical species react with specimens. This ensures there is no ion sputtering damage to delicate samples such as holey carbon/graphene grids.

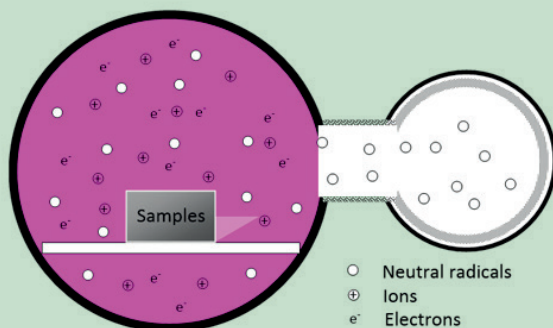
### Precise, mass flow gas control

Gases and gas mixtures are an important part of plasma treatment processes. For precise gas flow control and mixing, Tergeo-EM uses two mass flow controllers (MFC) as standard, with the option of a third if required. Calibrated for clean dry air, each MFC allows precise control of gas flow in sccm (standard cubic centimetres per minute). This provides more accurate control of gas ratios compared to systems with basic gas valves. For TEM and SEM applications, mixtures of argon, oxygen and nitrogen are typically used. For some EM applications, hydrogen can be used – and even clean dry air produces exceptionally good results.

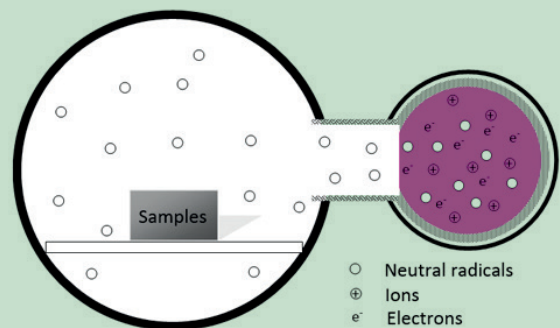
### Rapid pump down and cycle times

Tergeo-EM is completely self-contained and operated with an oil-free scroll pump for optimal performance. Rapid pump downtime to working pressure is less than one minute. Tergeo-EM is supplied complete with fittings for a working system. Optional accessories include additional TEM rod holders and a holder for up to 20 TEM grids.

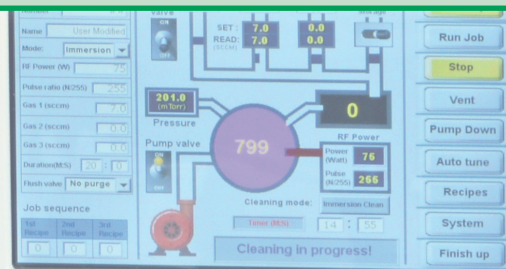
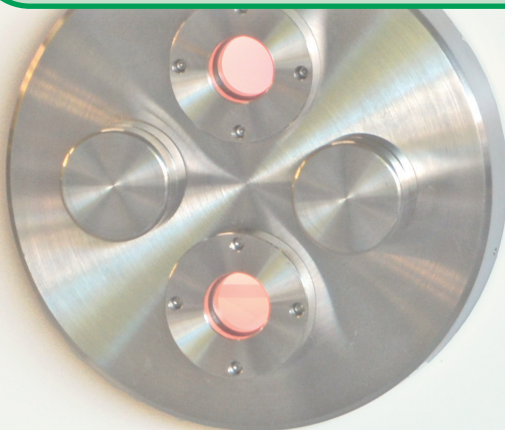
## Immersion and downstream cleaning – optimum for SEM and TEM applications



**Immersion mode** – for high-speed cleaning and etching



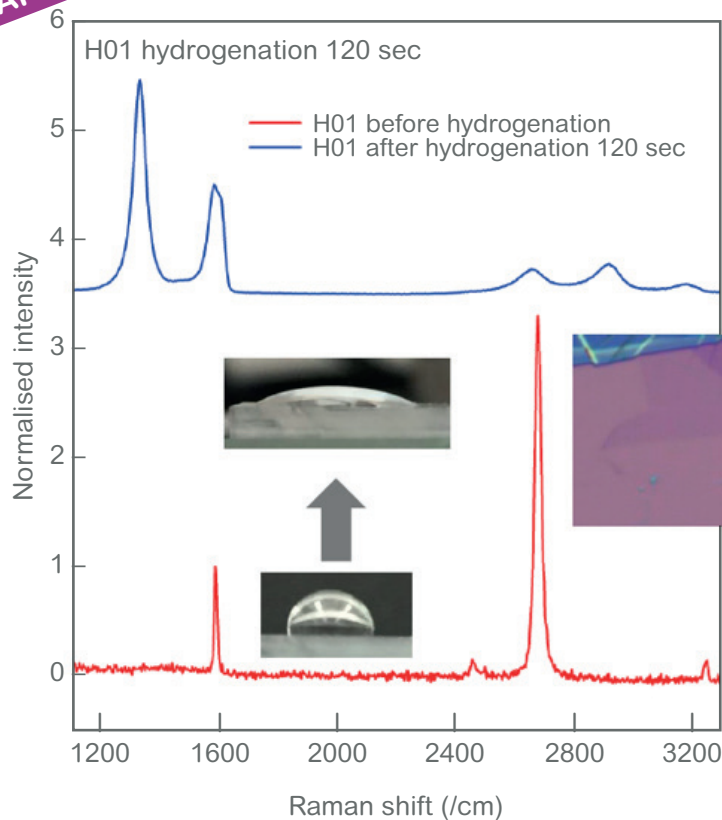
**Downstream mode** – for TEM and SEM specimens and other delicate specimens



# Tergeo EM Plasma Cleaner

## APPLICATION

## Hydrogenation of graphene

**Recipe:**

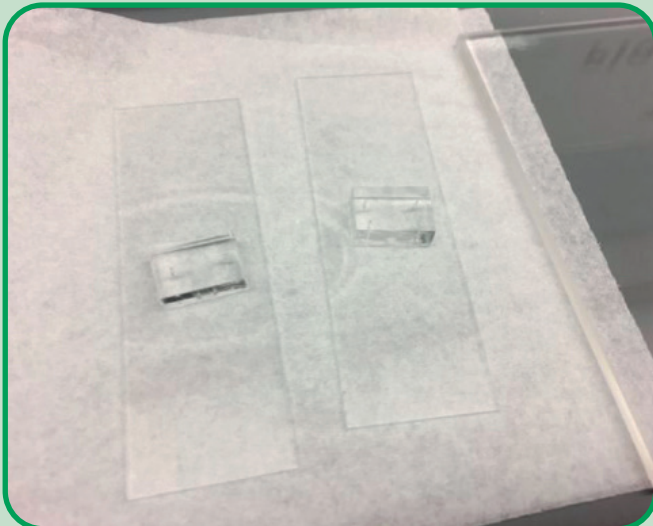
Remote mode, 10W RF power, 5sccm gas  
(H<sub>2</sub>: 2%, Ar: 98%, buffered, non-explosive gas)

After two minutes hydrophobic graphene was changed to hydrophilic hydrogenated graphene. The Raman spectrum confirms the hydrogenation results.

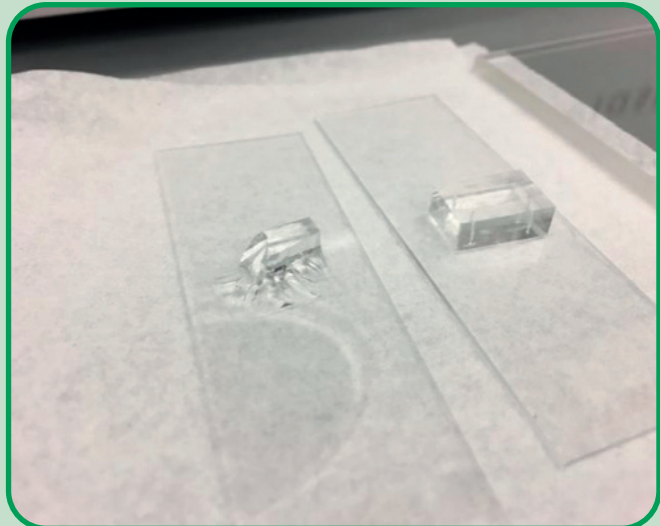
*Images: Dr. Jangyup Son at Professor Arend M. van der Zande's group at The University of Illinois Urbana-Champaign*

## APPLICATION

## PDMS-glass bonding



**Figure 1.** After plasma processing, PDMS bonds to the glass immediately. Any trapped gas at the interface is automatically squeezed out. Using plasma there is no need to cure the PDMS-glass bond in an oven, a process that can take two hours.



**Figure 2.** One minute after bonding an attempt is made to break the PDMS-glass bond, but the bond is so strong that the bond interface remains intact, even though part of the PDMS was ripped off during the removal attempt.

*Data provided by Dr. Marc Fouet at Professor Rine's laboratory at University of California, Berkeley*



## Other PIE Scientific plasma products

### EM-KLEEN

An advanced, on-chamber plasma cleaner for electron microscopes and other analytical instruments, including SEM, FIB, FIB/SEM, TEM, XPS and SIMS.

### Tergeo

Optimised for etching, ashing and surface treatment applications. Tergeo uses advanced RF plasma technology, including unique dual plasma strength sensing and pulsed plasma. 110mm Ø x 280mm quartz chamber and choice of 75W or 105W power.

### Tergeo-Plus

A large chamber (160mm Ø x 280mm) version of Tergeo suitable for 6" wafers.



## About PIE Scientific



PIE Scientific has a wealth of experience in plasma, ion and electron technology, having been founded by alumni of the Plasma and Ion Source Technology Group at the prestigious Lawrence Berkeley National Laboratory. PIE Scientific specialise in developing advanced plasma systems for etching, cleaning and surface treatment applications. PIE Scientific realised that many existing low-cost plasma cleaners use old and dated technology and set about bringing state-of-the-art technology and know-how into the development of affordable benchtop plasma instruments, such as the Tergeo-EM.



# Specifications

<b>RF power</b>	There are two options: 0-75W or 0-150W, 13.56mHz high frequency RF power with automatic impedance matching of in-situ plasma source
<b>Two process modes</b>	Dual plasma source. Immersion (direct) plasma for high-speed cleaning, etching and surface modification. Remote (indirect) plasma for gentle surface contamination removal and hydrophobic-hydrophilic conversion of carbon support films
<b>Pulsed operation</b>	Continuous or pulsed plasma, cycle time: 2ms. Pulse ratio: 0.4% to 100%. Controlled by setting the duty ratio (0-255) to generate plasma with average RF power down to less than 0.25W
<b>Automatic plasma strength sensor technology (patent pending)</b>	Monitors both direct and remote plasma sources. Plasma strengths are monitored and displayed in real-time on the central display
<b>Automatic sensing and process control</b>	For pressure, temperature, gas-flow rates and plasma strength. With automatic impedance matching
<b>Operating pressure</b>	0.07 to 1.33mbar
<b>Pumping</b>	Edwards premium dry scroll pump
<b>Vacuum guage</b>	Premium corrosion-resistant pressure sensor
<b>Process gas control</b>	Two mass flow controllers (MFC) for controlled gas flow (0~100sccm) fitted as standard. ¼ inch Swagelok compression fitting connectors. A third MFC is optional (see accessories)
<b>Plasma chamber door with TEM rod adaptors</b>	Accepts two TEM rod holders (of your choice). The door has two quartz observation windows to allow viewing of the chamber and plasma colour
<b>Quartz chamber and shelf</b>	ID: 110mm, depth: 280mm. Includes a quartz specimen shelf
<b>Port for venting and purging</b>	With clean dry air or other gases
<b>Graphical user interface</b>	With easy to use 7" resistive touchscreen. Up to 20 customisable recipes. Setting of all key process parameters. Help menu
<b>Instrument dimensions</b>	450mm (W) x 250mm (H) x 430mm (D) excluding pump
<b>Electrical requirement</b>	AC power 100~230V, 50/60Hz. The applicable European Community requirements for product safety are specified in EMC Directive 2004/108/EC and the Low Voltage Directive 2006/95/EC
<b>Remote diagnostics</b>	Remote online support and diagnostics. Tergeo-EM has a "Serial to PC" port for control from a PC user interface through RS232 communication port
<b>Warranty</b>	Two year factory warranty



# Ordering information

## Main instrument

Tergeo-EM tabletop RF plasma cleaner.

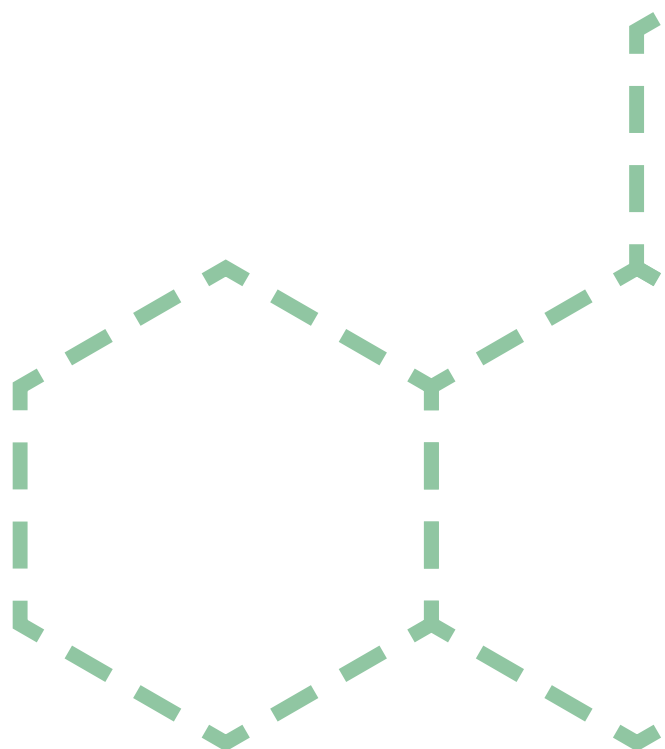
## Pump

Edwards nXDS6i dry scroll pump. Peak pumping speed:  $6.2\text{m}^{3\text{h}^{-1}}$ . Silencer for nXDS6i. NW25 flexible, braided, stainless steel vacuum hose (1,000mm) and fittings to scroll or rotary pump.

NB. Tergeo-EM can also be supplied instrument-only for users with an existing pump.

## Optional accessories

<b>PIE012</b>	RF power supply upgrade from standard 75W to 150W
<b>PIE015</b>	Third mass flow controller (MFC) if three gases are required
<b>PIE024</b>	Additional TEM rod adaptor (specify TEM holder type)
<b>PIE026</b>	20 position TEM grid holder
<b>PIE033</b>	Dust particle filter. Recommended when room air is used as a process gas and/or for venting the chamber
<b>PIE040</b>	Additional door without rod adaptors



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