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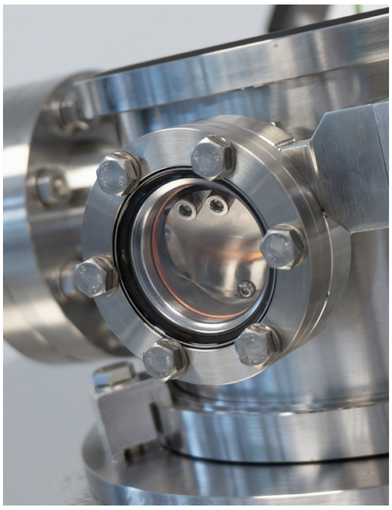
nanoCVD-WG(P)

Compact system for wafer-scale CVD synthesis of graphene, with optional plasma module



Key features:

- Compact, low-footprint design
- Wafer-scale synthesis: 3” or 4”
- 1100 °C maximum platen temperature
- Cold-walled technology
- MFC-controlled process gases
- Optional plasma module (RF, 13.56 MHz)
- Fully-automatic control of critical conditions
- User-friendly, touchscreen HMI interface
- Define/save multiple growth recipes
- PC connection for data-logging
- Equipped for easy servicing
- Comprehensive safety features
- Cleanroom compatible
- Implements proven nanoCVD technology

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Moorfield Nanotechnology Limited. Unit 1, Wolfe Close, Parkgate Industrial Estate, Knutsford, Cheshire, UK, WA16 8XJ.
Registered in England and Wales with company number 3044718.

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Overview:

Developed in collaboration with academic partners, nanoCVD technology is proven for the rapid-throughput production of high-quality graphene for R&D applications via the well-established chemical vapour deposition (CVD) route that is considered most promising for future commercialisation of graphene-based technologies.

Models WG (thermal only) and WGP (plasma-enhanced) are the result of the scaling of this technology to the wafer scale (3” or 4”), in a cold-walled, actively cooled chamber. While this represents a significant leap in the capabilities of the nanoCVD range, intelligent design means the compact nature of the units has been maintained for efficient location and integration.

System design:

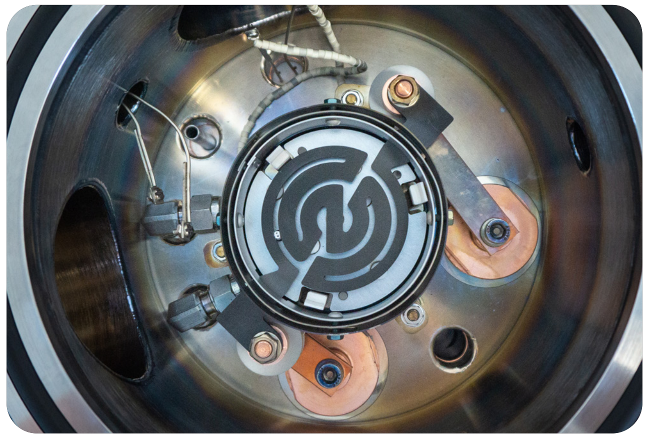
Cold-walled technology: In contrast to hot-walled systems that typically involve tube-type furnaces, in nanoCVD systems only the stage is heated. This enables better substrate temperature control, faster heating/cooling rates and efficient usage of high-purity process gases and electrical power.

Chamber, stage and pumping system: The tool contains a high-vacuum chamber. Inside, and at the base of the chamber, is a resistively heated substrate stage onto which foil or wafer substrates can be placed. While the system can accept wafer-scale substrates, it is equally possible to use smaller, ‘chip’-scale samples. The substrate stage is designed for uniform heating up to 1100 °C, with temperature control resolution to ± 1°C. For chamber access, the lid is easily closed and sealed. Chamber evacuation is via a turbomolecular pumping system for low base pressures of <5×10^{-7} mbar. This allows for low-contamination material synthesis.

Manual and automatic operation: After chamber evacuation, CVD processes can be operated in either manual or automatic modes. In automatic mode, the unit allows for flexible design of multiple-step processes, with control over all critical parameters including temperature, pressure and RF plasma power (if fitted). During process execution, all hardware is precisely controlled, automatically, by the on-board electronics.

Process gas introduction: The standard configuration is equipped for Ar, H_2 and CH_4 process gases, with flows controlled by mass-flow controllers (MFCs). With respect to process gas introduction, the system can be operated in two ways: flow-rate and pressure control. For flow-rate control, users define required MFC flow rates that the system then implements. For pressure control, the unit automatically sets pumping system state and gas flow rates in a dynamic fashion to achieve defined pressure setpoints. For this latter mode, pressure monitoring is via a high-resolution capacitance manometer.

High vacuum chamber, HMI, and pumping system to the rear.



Chamber with lid opened to reveal inner components and heat shielding. The capacitance manometer and wide-range gauge for pressure measurement are visible to the right of the chamber.

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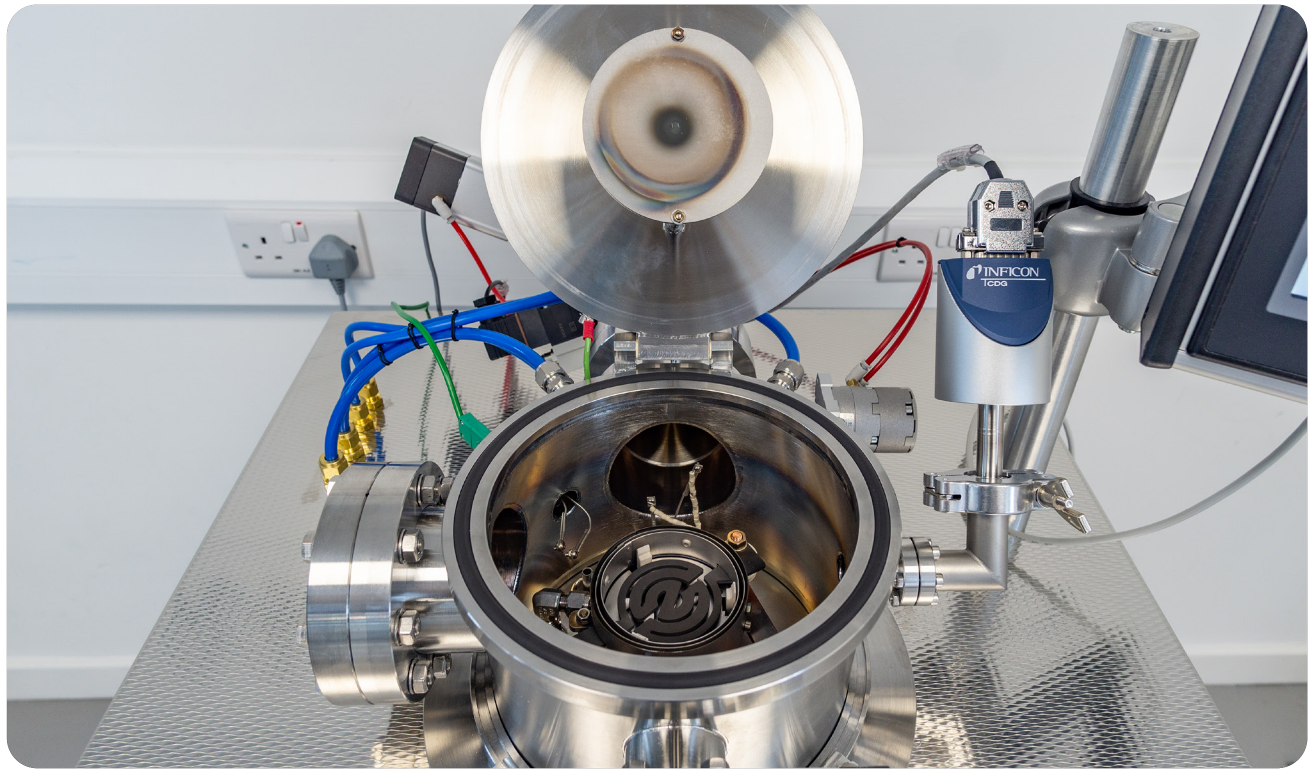
Plasma module (model WGP): For customers requiring plasma-enhanced processes, the system can be fitted with the plasma module. This includes a 150 W RF power supply (13.56 Mhz) and upgrades to the stage to allow for plasma generation. Users can determine required plasma power levels with 1 W resolution. Uniquely, model WGP can also be configured to allow for direction of RF bias to multiple in-chamber electrode surfaces: the substrate platen and a second, ‘top’ electrode located above the substrate surface. The vertical position of the top electrode can even be adjusted via a Z-shift, allowing for plasma generation at well-defined remote distances from the substrate surface (e.g., for balancing etching and synthesis effects).

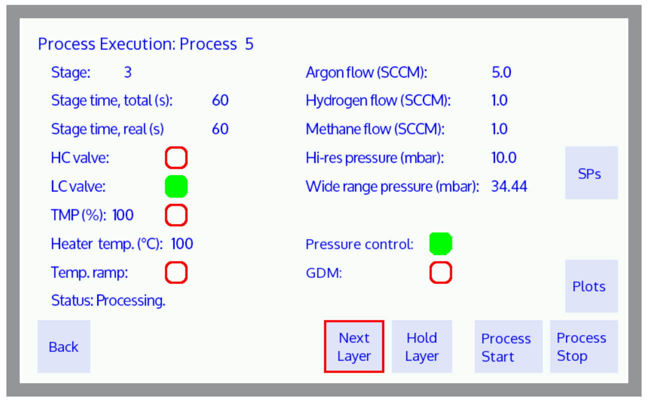
Safety features: The unit is equipped with an emergency-off switch and multiple interlocks based on coolant flow and chamber vacuum levels. In addition, on-board electronics perform continuous hardware checks; in the event of any issue, the system is locked down to a safe state until normal conditions are resumed.

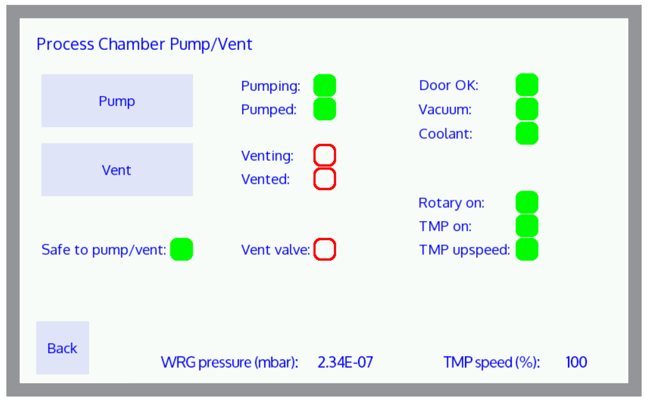


Lid of the opened chamber, self-supported in the retracted position. Visible here is the top electrode. The vertical position of this can be adjusted, allowing for plasma generation in a controlled remote location with respect to the substrate.

Control system:

The unit is fitted with industrial-grade, high-stability PLC electronics. User operation is via a 7” touchscreen HMI mounted on the front panel. Users are able to define, store and run multiple ‘recipes’ via flexible, but easy-to-use, touchscreen software. Online data-logging and recipe upload/download to a PC is possible via the provided NanoConnect software.





Screenshots from the touchscreen HMI software through which all user operation of the nanoCVD is carried out

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PRODUCT INFORMATION

References (nanoCVD Thermal-CVD Graphene Growth):

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2. Neves, A. I. S., et al. "Transparent Conductive Graphene Textile Fibers" Sci. Rep. 2015 DOI: 10.1038/srep09866
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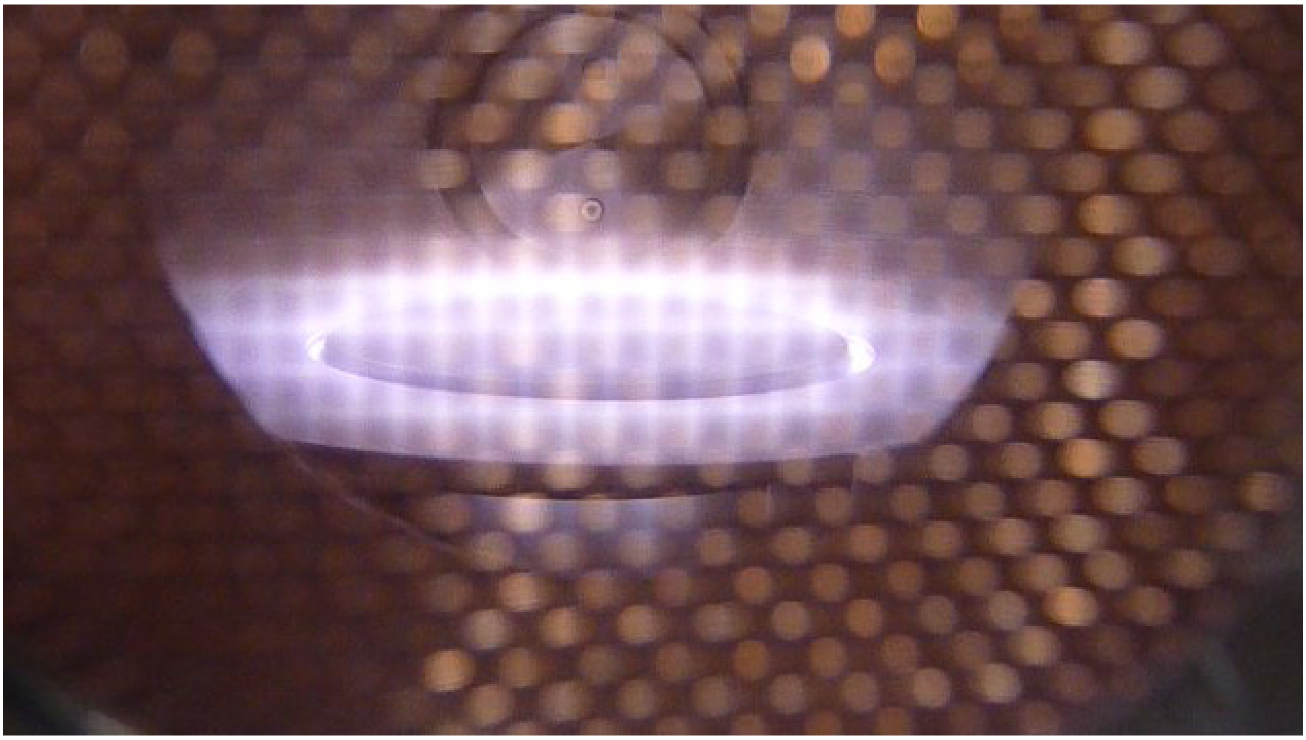

Plasma generation through application of bias to the heated substrate stage.

System requirements: (standard configuration)

- Substrates: Typically foils or films (including on wafers) of various metals
- Process gases: 25 psi supplies of methane, hydrogen and argon
- Service gas: Dry inert (e.g., nitrogen or argon), 60–80 psi supply
- Coolant: 18–20 °C coolant/water flow, 3 kW cooling power
- Power: Single-phase 230 V, 50 Hz, 16 A
- Exhaust extraction

Applications:

- Fundamental research
- Education
- Product R&D and pilot-scale production

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BT Electronics certifié ISO 9001 par AFNOR

Phone +33 (0)1.69.18.16.60
Web bt-electronics.com
Email contact@bt-electronics.com

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