



APT-100/110/125 series ICP/RF plasma systems

Application: The 2nd generation ICP/RF (radio frequency) plasma system with regulated up to 35-40 kW power in plasma plume (power depends on many factors, including plasma gas composition and flow) is developed for continuous operation on different gases, including Ar, air, N₂, He, CO₂, blends of air and O₂, Ar + O₂, Ar + N₂, and others with pressure at the torch output from several Torr to 7 bar. The system allows remote plasma initiation at 1 bar pressure, automatic switching of plasma gases, visualization of the operation parameters as real plasma power and temperature, plate voltage and current, grid current, consumed from grid power, temperature and flow of water in the cooling loops, data logging, etc. Could be used for industrial purposes and at research facilities.

Components: The plasma system consists of a Direct Current (DC) Module with dimensions (vary depending on applications and input voltage) 34" x 50" x 70" for 480V input, weight 1,100 kg (standard); Radio-Frequency (RF) Module with dimensions 34" x 34" x 68", weight about 400 kg; coaxial cable 2-2.7 m total length; Matching Network 12" x 12" x 23", Gas supply module 12" x 12" x 23" and plasma torch with replaceable nozzles for multiple applications. Optionally, the gas supply system pre-calibrated for up to 6 gases and remote operator's console are available.

Parameters:

- Input voltage – 3 x 480VAC, 60 Hz or 3 x 380VAC, 50 Hz
- Input power – 100 kVA max, 150 A
- Output voltage – up to 14,000 V
- Frequency – 2-5 MHz
- Cooling water – input 3/4" NPT female, output 1" NPT female. Flow rate for full power operation is 30 - 40 liters per minute
- Plasma gas flow – from 1.0 to 5 g/s (depending on gas composition and torch power).

Control system.

- Standard control system allows selection of manual and automatic operation modes from a 12-inch touch screen on the DC module front door, main parameters visualization, as anode voltage and current, grid current, anode and plasma power, input and output water temperature, water temperature after tube, and water flow rate, plasma plume power and average plasma temperature, data logging.
- Additionally to a set of functions for the standard system, the advanced one offers automatic ignition at 1 bar pressure, transition to different plasma gases, filament voltage control, remote flow and power control, plasma stabilization, gas valves monitoring, diagnostic tools with numerous user prompts, remote control from the operator's console or through profibus, and many others.

Front panel of the DC module and optional remote operator's console are depicted in Fig.3 and Fig.4 correspondingly.

Prospective applications :

- (1) Imitation of re-entry conditions for the Thermal Protection Material tests
- (2) Synthesis of new materials - solids and gases, nanostructures
- (3) Gasification of different feedstock - coal, sewage sludge, etc.
- (4) Powders processing for surface and property modifications, minerals extraction
- (5) High flow and concentration NO_x production – by 7% (mass).

Services:

- Development, production, commissioning, and worldwide maintenance of technologies based on ICP/RF plasma
- RF plasma diagnostics and modeling.

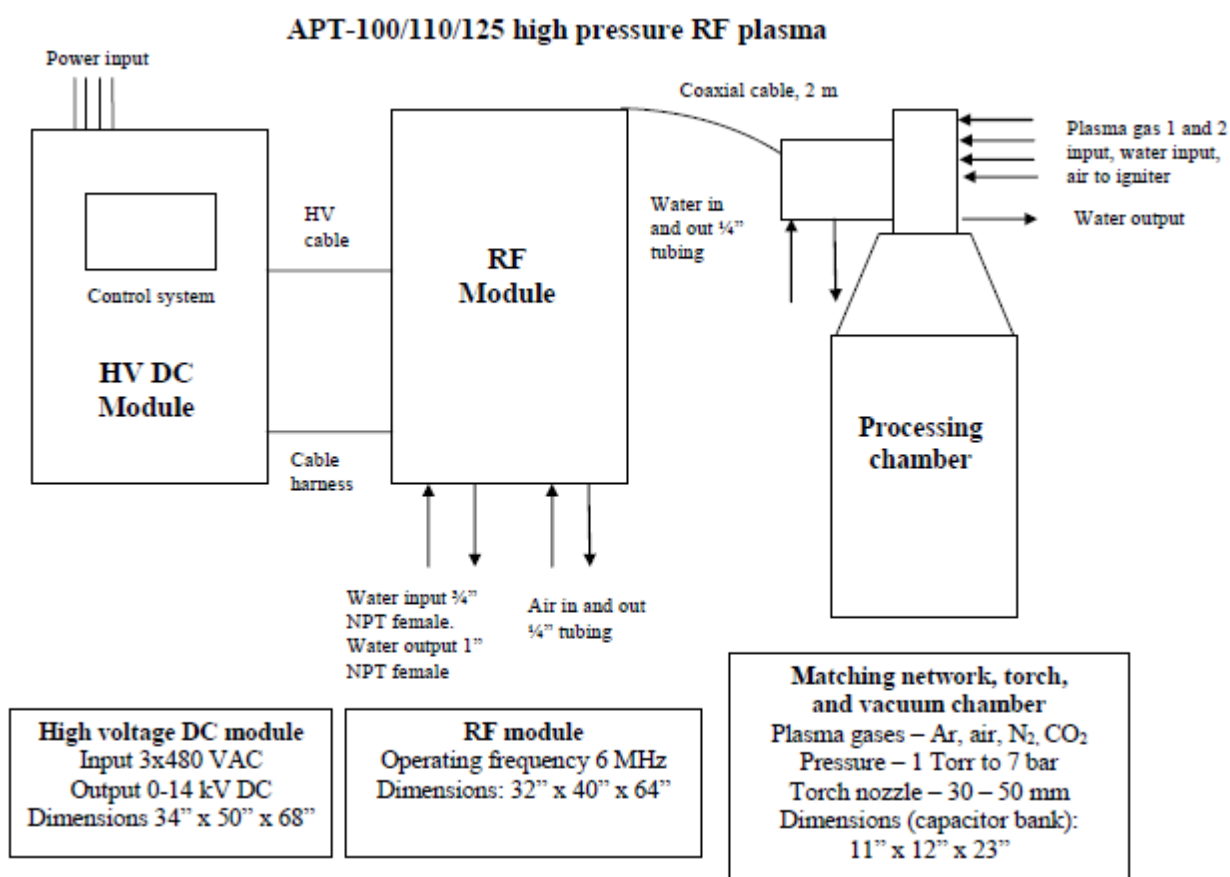


Fig.1. Configuration of APT-100/110/125 for synthesis of new materials.

Main parameters of APT-100/110/125

| | Parameter | Value |
|---|--|--|
| 1 | Flow OD at the torch output (prior to flow modifier), mm | 50 |
| 2 | Plasma gases | Ar, air, N ₂ , CO ₂ , oxygen enriched air, other |
| 3 | Plasma gas flow, g/s | 1.0 - 5.0 |
| 4 | Free stream enthalpy, MJ/kg | 3.0 – 35.0 |
| 5 | Average plasma plume temperature, °C | 2,500 – 7,000 |
| 6 | Operation pressure (pressure in induction section) | 1 Torr to 7 bar |
| 7 | Stagnation pressure, kPa (mBar) | 80 (800) |
| 8 | Maximal plasma plume power at the nozzle cross section, kW | 30 - 35 |
| 9 | Maximal apparent power consumption, kW | 97 |
| | Plasma generation efficiency – plume power/anode power | 0.4 – 0.55 |



Fig.2. General view of the APT-125 plasma system for nanostructures production. APT facilities in Marshall, VA. June, 2023.

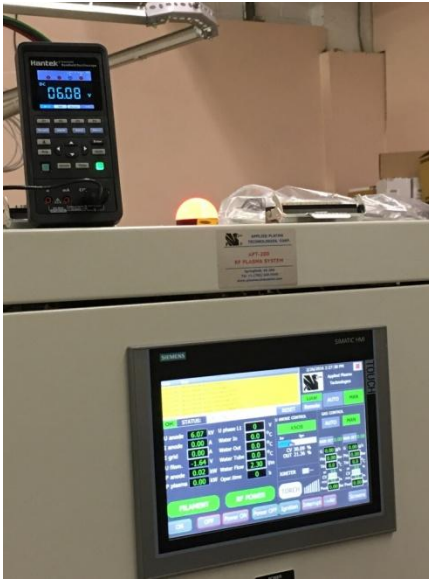


Fig.3. Touch screen with parameters



Fig.4. Remote operator's console



Fig.5. Torch operation and plasma diagnostics by optical spectroscopy