Introduction

The Thermo Scientific APIX δQ analyzer is the choice for continuous quality control of bulk gases in the semiconductor and electronics industries, due to its superior performance of API-MS, state-of-the-art electronics and powerful process analysis software.

An API-MS offers a cost-effective alternative to conventional quality control techniques, allowing each bulk gas to be monitored for a range of potential contaminants, while achieving lower detection limits (up to 100 times better) than any other technology.

The APIX δQ analyzer provides a more complete analysis of impurities in the electronics industry, including H2, CO, CO2, H2O, O2, CH4, Kr and Xe.
with other impurities available. With the advent of 300 mm wafer manufacturing placing even tighter impurity controls on gas quality standards, this technology will continue to be the preferred method for ppt level detection.

Easily programmable short cut keys allow you to jump directly to frequently accessed functions, menus or screens. The larger interface screen can display up to five lines of measurement information while the primary screen remains visible.

**Gas analysis applications**
- UHP Nitrogen
- UHP Argon
- UHP Helium
- UHP Hydrogen

**Principles of operation**
The APIX δQ and APIX Quattro begin with sample gas flowing into the ion source at slightly higher than atmospheric pressure. A corona discharge is produced by a needle maintained at a high voltage which is located close to an orifice plate that forms the entrance to the lens stack. This results in a stream of electrons which flow from the orifice plate to the needle. The electrons react with the bulk gas which causes ionization of a large number of bulk gas molecules. Fortunately, the rare contaminating molecules that might occur in the bulk gas are thermodynamically more favorably ionized than the bulk gases nitrogen, hydrogen, helium or argon. For this reason, when any contaminating molecule appears in the sample stream, there is a very high probability that it will react with a bulk gas ion. When this reaction occurs, the charge is transferred to the contaminant, which then becomes ionized. This charge transfer results in a very high proportion of the contaminant molecules becoming ionized. In fact, the efficiency is about 1,000 times that of other ionization techniques that operate through a series of pressure reducing lenses before it enters the quadruple mass spectrometer. A triple-filter unit is used that permits measurements up to 200 Daltons (atomic mass units) allowing the contamination species signals to be measured at the detector. The pulse counting amplifier has a noise level of just $10^6$ counts per $10^{12}$, when combined with the API source, enabling detection of individual species as low as 10 parts in $10^{12}$ (10 ppt).

**Configuration**
The APIX δQ configuration comprises a single-bay environmental enclosure containing the API-MS analyzer and the Air Liquide™ gas processor. The system can be offered with optional dry pumps for a clean room compatible solution. The APIX Quattro configuration is comprised of two single-bay environmental enclosures which contain four API-MS analyzers and the third bay houses the Air Liquide gas processor that provides automatic ppb or ppt calibration of the analyzers. Each of the four mass spectrometers is mounted on slides in order to be pulled forward for easy maintenance. The top-mounted hood can contain stream switching manifolds for sample gas connections, allowing multiple streams to be connected to each independent bulk gas analyzer.

This stream selection can be manually controlled or fully automated. The hood assembly in both configurations incorporates a hydrogen safety system that ensures the mass spectrometers are safely shutdown in the event of a hydrogen leak. This safety device works independently of the analyzer power supplies. If limited mobility is required, a set of wheels can be provided that allow the unit to be safely pushed from one test point to another.

Each mass spectrometer is controlled by an embedded processor that runs a real-time operating system using battery-backed flash memory. The processor acts as a master to a series of internal controllers, interconnected by Ethernet cable. Each of these microcontrollers operates the individual subassemblies such as the gas processor and multi-stream inlet. The gas processor requires only a single calibration cylinder and incorporates a moisture calibration from a permeation tube device. Internal power distribution is monitored and controlled by the local analyzer network—a design feature that extends the diagnostic abilities to Thermo Scientific™ GasWorks® software.

Each multi-processor analyzer network provides redundant communication channels to permit reliable, stand-alone operation without the need for a PC workstation, transmitting sample stream data and...
diagnostic information directly to the DCS or SCADA system. Each analyzer has two serial ports which can be configured for RS232, RS422 (4 wire, full duplex) or RS485 (2 wire, half duplex) communication. Each analyzer can be configured with an embedded OPC server for seamless communications with a Microsoft® host or with an industrial gateway protocol such as Modbus or Siemens®3964R. There are also options for analog and digital outputs if required.

**Thermo Scientific™ GasWorks® software**

The Thermo Scientific GasWorks software provides an intuitive, information rich and flexible window into the operation of the mass spectrometer. Initial setup uses the remote computer which can then be used to display process measurement and diagnostic data, or it can be unplugged leaving the individual APIX to operate in full stand-alone mode. The software installation can be checked at anytime to ensure that it is verifiably complete and correct. Software updates can be uploaded remotely.

![Graph showing daily temperature effects observed at a semiconductor fab over a period of seven days.](image)

This graph shows the daily temperature effects observed at a semiconductor fab over a period of seven days.

![Graph showing impurity concentration in PPT over time.](image)

The trace shows relatively high methane concentrations in the "pure" nitrogen and an effective repair which resulted in the methane returning to normal levels well below 10 ppt.

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**Instrument Layout**

The APIX δQ configuration is comprised of a single-bay environmental enclosure containing the API-MS analyzer and the Air Liquide gas processor.

The Thermo Scientific™ APIX Quattro configuration is comprised of two single-bay environmental enclosures which contain four API-MS analyzers and the third bay houses the Air Liquide gas processor that provides automatic ppb or ppt calibration of the analyzers. Each of the four mass spectrometers is mounted on slides in order to be pulled forward for easy maintenance access. The top-mounted hood contains the sample gas connections and any stream switching manifolds. Stream selection can be manually controlled or fully automated.
Thermo Scientific APIX δQ and APIX Quattro Electronic Gas Analyzer

### Specifications

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<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Bulk gas suitability</strong></td>
<td>H₂, N₂, Ar, He</td>
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<tr>
<td><strong>Impurities monitored</strong></td>
<td>H₂, CH₄, H₂O, CO, N₂, O₂, Ar, CO₂, Kr and Xe (depending on bulk gas)</td>
</tr>
<tr>
<td><strong>Ion source</strong></td>
<td>Atmospheric pressure ionization</td>
</tr>
<tr>
<td><strong>Ion source background</strong></td>
<td>Less than 10 ppt</td>
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<tr>
<td><strong>Mass range</strong></td>
<td>2-200 amu</td>
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<tr>
<td><strong>Amplifier and dynamic range</strong></td>
<td>100 MHz pulse counting type</td>
</tr>
<tr>
<td><strong>Detector</strong></td>
<td>Pulse counting channel electron multiplier</td>
</tr>
<tr>
<td><strong>Detection noise</strong></td>
<td>10 counts in 10⁻⁶</td>
</tr>
</tbody>
</table>
| **Lower Detection limits**    | Bulk N₂: 10 ppt for O₂, CH₄, CO₂, Kr and Xe; 30 ppt for H₂O, 50 ppt for CO; 150 ppt for H₂  
                               | Bulk Ar: 10 ppt for O₂, CH₄, CO, CO₂, Kr and Xe; 30 ppt for H₂O, 100 ppt for H₂  
                               | Bulk He: 10 ppt for O₂, CH₄, CO, CO₂, N₂, Ar, Kr and Xe; 30 ppt for H₂O; 50 ppt for H₂  
                               | Bulk H₂: 10 ppt for CH₄ and CO₂; 30 ppt for O₂ and H₂O; 150 ppt for N₂+CO combined |
| **Analysis time**             | Cycle time 2 minutes                                                   |
| **Stream switching time (typical)** | 15 minutes to < 1 ppb                                |
| **Serial connections**        | RS232, RS422, RS485                                                    |
| **Dimension**                 | APIX δQ: 1.9 m (H) × 0.7 m (W) × 0.65 m (D) (74.80 in × 27.56 in × 25.59 in)  
                               | APIX Quattro: 1.9 m (H) × 2.1 m (W) × 0.65 m (D) (74.80 in × 82.68 in × 25.59 in) |
| **Maximum number of components** | Not limited by software                                    |
| **Maximum number of peaks**   | Not limited by software                                                |
| **Maximum number of derived values** | Not limited by software                            |
| **Maximum number of methods** | Not limited by software                                                |
| **Maximum number of sequences** | Not limited by software                               |
| **Maximum number of analog I/O** | No fixed limit                                      |
| **Maximum number of digital I/O** | No fixed limit                                            |
| **Maximum number of trend windows** | No fixed limit                                               |
| **Communication protocols**   | Modbus, Siemens 3964R, OPC, VGCP, PVGCP                            |

Thermo Scientific instruments are recognized for outstanding performance and reliability. To ensure maximum uptime, we offer comprehensive service and support programs worldwide on all products via a network of factory-trained and highly qualified scientists and engineers. Our experts will keep your analyzer working to specification.

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