

The Next Stage of Thermal Desorption Analysis with Direct Silicon-Temperature Measurement

ESCO-TDS1200II IR BGM

The ESCO-TDS1200II IR BGM is an infrared-lamp-heated thermal desorption spectroscopy (TDS) system equipped with a band-gap monitor for direct in-situ determination of silicon temperature, supporting temperature-resolved analysis of desorption from thin films and silicon substrates.

A New Approach to Temperature Measurement in Thermal Desorption Spectroscopy (TDS)

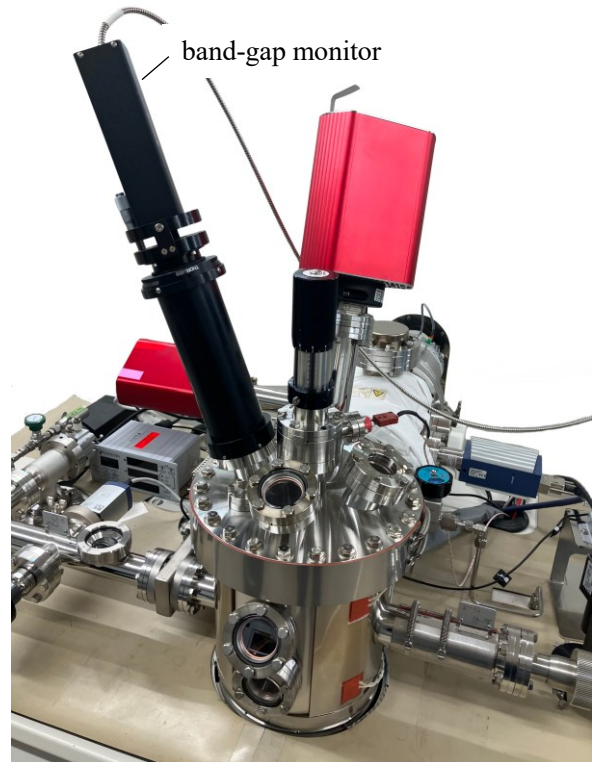
In TDS, temperature is one of the most critical parameters for interpreting desorption phenomena. Conventional systems typically control heating based on a thermocouple reading from a sensor placed beneath or in contact with the sample. However, accurate conversion from the thermocouple temperature to the actual sample temperature requires complex calibration procedures. Even after calibration, an inherent temperature offset can remain between the sample and the thermocouple reading.

The ESCO-TDS1200II IR BGM addresses these challenges by directly measuring the temperature of silicon in the sample using a **band-gap monitor**, while preserving the advantages of IR-lamp heating (rapid ramping and short measurement time). By exploiting the physical property that the silicon band gap depends on temperature, the sample temperature can be optically tracked in real time and fed back to the heating control.

This approach enables stable temperature measurement and heating-rate control over approximately 75–500 °C. Even under fast ramping conditions, the sample temperature is determined quickly, substantially expanding the flexibility and reliability of temperature control in TDS.

In particular, the method provides strong value for samples that include a silicon substrate, such as various thin films on the silicon surface. By enabling clear temperature-axis separation of desorption from physisorbed water and more strongly bound water-related species, the system captures desorption phenomena reflecting surface and film bulk in greater detail.

While maintaining the wide operating range of conventional systems (room temperature to 1200 °C) and the advantages of IR heating, the ESCO-TDS1200II IR BGM advances the concept of temperature measurement in TDS and provides new opportunities for materials evaluation and process development.



Key Features



Rapid Temperature Ramping and Short Measurement Time with IR-Lamp Heating

The **ESCO-TDS1200II IR** series, including the IR BGM model, uses infrared-lamp heating concentrated around the sample, as shown in Fig. 1. This enables rapid temperature ramping suitable for TDS and reduces heating of the entire chamber. The system supports ramp rates of 60 °C/min and enables measurements in approximately 20 minutes per run.



High Throughput with Short Cooling Wait Time

Because heating is concentrated around the sample, the chamber cools more quickly after each run. The typical wait time from the end of one run to the start of the next is approximately one hour, supporting high-throughput routine evaluation for materials and process studies.



Direct Silicon-Temperature Determination by Band-Gap Monitoring

The **ESCO-TDS1200II IR BGM** optically determines the temperature of silicon in the sample by tracking the temperature dependence of the silicon band gap in real time. This enables stable temperature measurement and ramp-rate control over 75–500 °C.



Stable Heating-Rate Control Under Fast Ramping

Real-time temperature determination enables feedback control of lamp power to maintain a constant heating rate even under fast ramping conditions. This improves temperature-control reliability while preserving the benefits of IR-lamp heating.



Temperature-Resolved Evaluation of Desorption from Thin Films and Surfaces

The system is suitable for thin films formed on silicon substrates. It enables temperature-resolved discrimination between desorption from weakly adsorbed water and more strongly bound water-related species, supporting evaluation of surface conditioning and desorption behavior related to film quality.

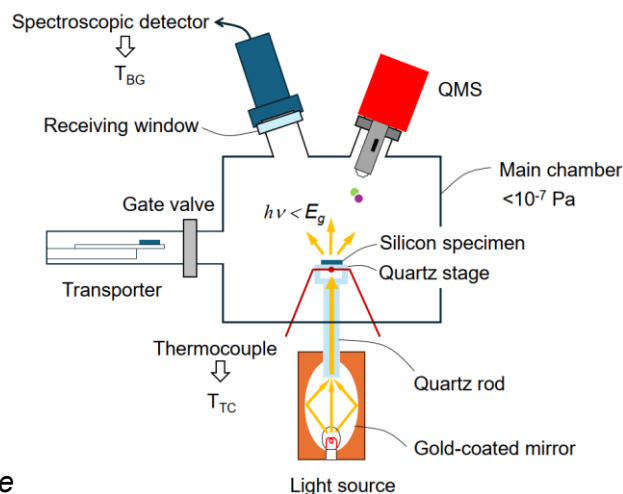


Figure 1. Schematic of a TDS system equipped with a band-gap monitor. Broadband white light (visible to near-infrared) emitted from a light source passes through a high-purity quartz rod and irradiates a silicon sample on a quartz stage in an ultrahigh-vacuum chamber. A spectroscopic detector collects part of the transmitted light through a receiving window.

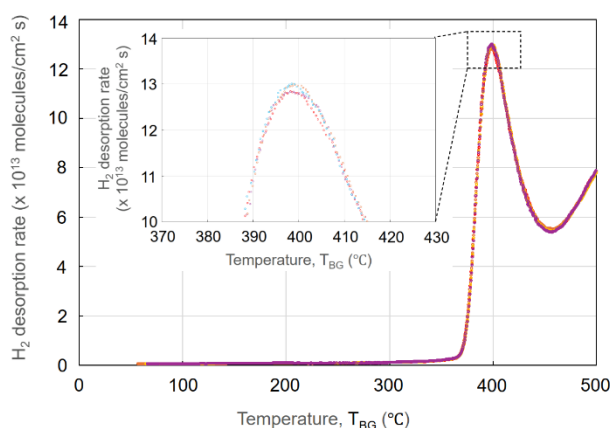


Figure 2. Relationship between the H_2 desorption rate and the sample temperature T_{BG} determined by the band-gap monitor for multiple samples prepared under identical conditions, measured at a heating rate of 0.5 °C/s. Sample preparation: a p-type (100) silicon substrate with a 10-nm SiO_2 film was implanted with hydrogen ions at 40 keV (dose: $1.1 \times 10^{17} \text{ cm}^{-2}$). All desorption peaks appeared within $398 \pm 1 \text{ °C}$, and the peak-temperature reproducibility was high (standard deviation: 0.5 °C).



Wide Measurement Temperature Range

The **ESCO-TDS1200II IR** supports TDS from room temperature to 1200 °C using thermocouple-based control. The **ESCO-TDS1200II IR BGM** retains this capability while adding band-gap-based temperature determination to enable flexible measurements depending on application.

Applications

Details of the measurement examples below will be presented at the Advanced Semiconductor Manufacturing Conference (ASMC) 2026.



Desorption Behavior of Water Adsorbed on Oxide-Film Surface

For SiO_2 films formed on silicon substrates, desorption of water-related species originating from both the film surface and the film bulk can be observed. Using the ESCO-TDS1200II IR BGM, these desorption behaviors can be clearly separated and evaluated on a temperature axis. In the measurement example shown in Fig. 3, a low-temperature desorption peak is observed in the range of approximately 100–200 °C, which is considered to originate mainly from water molecules weakly bound on the oxide surface. In contrast, above 300 °C, other desorption peaks appear at higher temperatures, reflecting desorption of more strongly bound water-related species. By using the band-gap monitor, these desorption temperatures can be measured stably, enabling discussion of physisorbed water and more strongly bound water-related species based on their desorption temperatures.



Re-adsorption Behavior of Water Induced by Air Exposure

In another measurement example, samples that had been dehydrated at a high temperature were subsequently exposed to air, and recovery of the low-temperature H_2O desorption peaks was observed over time. In contrast, the high-temperature desorption peak showed little recovery after short air exposure, suggesting that the re-adsorption behavior depends on the state of the water-related species. The ability to compare these distinct behaviors is a key feature of this system.



Thermal Stability Evaluation of Thin Films (e.g., IGZO)

In oxide semiconductor, desorption of water-related species and metal constituents can affect electrical performance and reliability. The ESCO-TDS1200II IR BGM captures both water desorption and metal-related desorption in higher-temperature ranges, supporting thermal process-window studies.



From R&D to Production-Process Evaluation

Combining IR rapid ramping/short measurement time with band-gap-based temperature determination enables broad usage from R&D to production-oriented process screening, including materials research, process evaluation, and quality control.

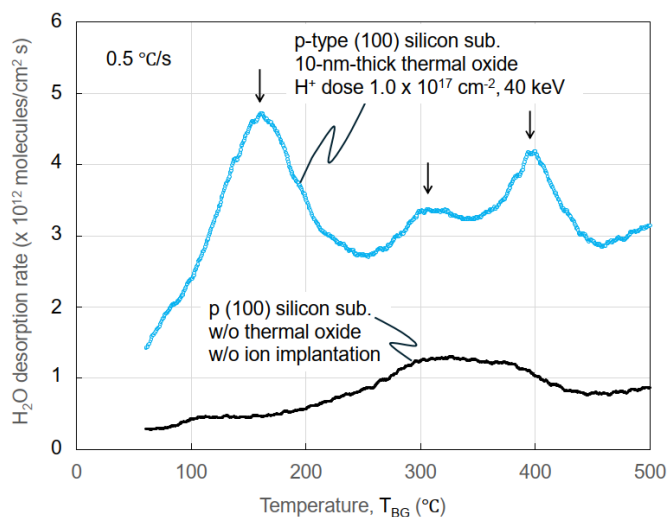


Figure 3. H_2O desorption behavior was analyzed using a p-type (100) silicon substrate with a 10-nm-thick SiO_2 film, implanted with hydrogen ions at an acceleration energy of 40 keV with a dose of $1.1 \times 10^{17} \text{ cm}^{-2}$. Three H_2O desorption peaks were observed at approximately 168, 315, and 398 °C. The low-temperature peak is considered to originate from physisorbed water, whereas the two higher-temperature peaks are attributed to hydroxyl groups and water incorporated within the SiO_2 network. This apparatus facilitates the separation of the contributions of physisorbed water and more strongly bound water species and is useful for evaluating the H_2O adsorption state on the surface.

Technical Data of ESCO-TDS1200II IR BGM

Max sample size	15 × 15 × 4 mm
Sensitivity	1 × 10 ¹¹ molecules/s (Ar)
Repeatability	< 5% (2σ, 1 day)
Main chamber	
Gas detector	Quadrupole mass spectrometer Range : 1 ~ 199 Da (Option: mass range customization) Resolution: (M/ΔM) ≥ M
Pressure gauge	BA-Pirani combination gauge Measurement range: 5 × 10 ⁻⁸ ~ 1 × 10 ⁵ Pa
Temperature measurement	Stage build-in thermocouple (Type C) Sample-contacted thermocouple (Type C) (option: Infrared thermometer)
Band gap monitor *	Band gap monitor *
Vacuum pump	Turbomolecular pump (400 L/s) Rotary Pump (200 L/min) (option: Dry pump)
Chamber	Internal volume: 10 L Ultimate pressure: ≤ 5 × 10 ⁻⁷ Pa
Load-Lock chamber	
Pressure gauge	Cold cathode – Pirani combination gauge Range : 1 × 10 ⁻⁷ ~ 1 × 10 ⁵ Pa
Vacuum pump	Turbomolecular pump Rotary pump (option: Dry pump)
Chamber	Internal volume: 1 L Valve: CF2.75" UHV gate valve
Temperature Control	
Temperature range	< 50 ~ 1200°C
	75 ~ 500°C (when using Band gap monitor) *
Heating rate	1°C/min ~ 180°C/min (thermocouple)
	10, 30, 60°C/min (when using Band gap monitor) *
Max temperature program	100 steps
Heat Source:	IR light guide 1 kW halogen lamp

* not included in ESCO-TDS1200 II IR

Technical Data of ESCO-TDS1200II IR BGM

Software	
BGM temperature feedback control *	BGM temperature feedback control *
Measurement program	Real-time monitoring of QMS intensity, time, pressure, and temperature Easy setup of QMS settings and Temperature program Automatic start/stop function for measurement (time, temperature, pressure)
View and Analysis program	Graph display and output (temperature, pressure, TDS spectrum, mass spectrum, 2D, 3D) Background correction (minimum value, spline, exponential, blank data) CSV output (time, temperature, pressure, QMS Intensity, desorption rate) Quantification (H ₂ , CH ₄ , H ₂ O, N ₂ , CO, O ₂ , CO ₂ , others)
Applications	Evaluation of surface water Desorption behavior analysis of thin-film materials High-precision measurement of desorption peak temperature Derivation of activation energy of the desorption process

* not included in ESCO-TDS1200 II IR

Contract Analytical Services

Leveraging the expertise gained as a specialized manufacturer of TDS instruments, we provide contract measurement services. Instruments are maintained in good condition and operated by skilled, dedicated operators.

Equipment line for the contract analysis services

1. ESCO-TDS-1200II IR
2. **ESCO-TDS-1200II IR BGM**
3. ESCO-TDS1700 IH
4. ESCO-TDS-(minus)100 Cryo H2 (Launching Soon)

Measurement Examples

Desorbed molecules from oxide, nitride, IGZO, and metal films, Hydrogen analysis in electroplated metal films,
Photoresist residue analysis, Oxyhydrides (powders), Impurity evaluation in ceramics and oxides, Hydrogen analysis in steel

Our service process

STEP 1: Consultation & Quotation

Contact us via our inquiry form or email with your measurement objectives and sample details (e. g., material, dimensions). We will review your requirements and provide a formal quotation. sales@escoltd.co.jp

STEP 2: Order & Scheduling

To proceed, please submit a purchase order (PO). Once your order is confirmed, we will work with you to schedule the measurement date.

STEP 3: Sample Shipment

Please ship your samples to our facility to arrive at least one business day prior to the scheduled measurement.

STEP 4: Measurement & Reporting

We will perform the measurement and deliver a comprehensive report, typically within one week of the measurement date.

A Note on Sample Return:

The client is responsible for all costs associated with return shipping, including shipping fees, customs duties, and taxes.

Contact & Inquiries

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