Application Note 20251114v5 Published: Nov 14, 2025

Hydrogen Desorption (TDS) in SiN_x Thin Films using ESCO-TDS1200II IR

Summary

Using an infrared-heating TDS system (Model: ESCO-TDS1200II IR), we evaluated hydrogen desorption in SiN_x thin films. Three H_2 desorption peaks were observed at 450 °C, 570 °C, and 980 °C. The low-temperature peaks are consistent with surface-origin species on the native oxide (H_2O or H), whereas the high-temperature peak reflects bulk hydrogen (N–H and Si–H). These results provide actionable guidance for pre-clean, deposition, and annealing optimization.

Detailed Description

1. Sample & Instrument

Infrared-heating-type thermal desorption analyzer ESCO-TDS1200II IR) was used (See Fig. 1). The samples were heated under ultrahigh vacuum (<1×10^{-7} Pa) with 60 °C/min up to 1100 °C. The sample temperatures were measured by a pyrometer.

We prepared two samples, A and B, with a SiN_x/Si structure shown in Fig. 2. The SiN_x films with a thickness of 17.9 nm were grown on p-type (100) silicon substrates using an LPCVD technique with the SiH_2Cl_2-NH_3 system at 650 °C.

H_2 desorption in the two samples, A and B, was investigated.

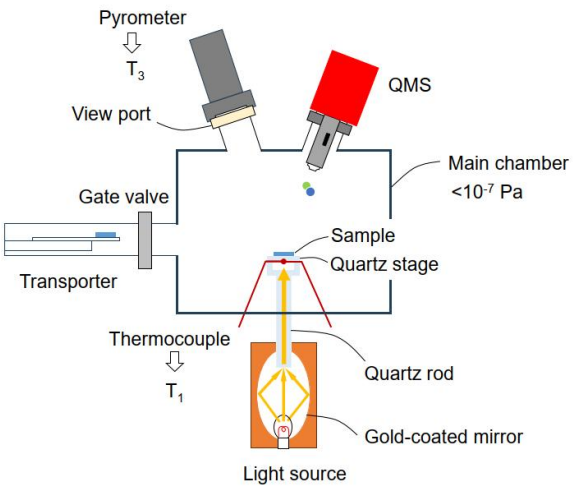

Fig. 1 Infrared-heating-type thermal desorption analyzer

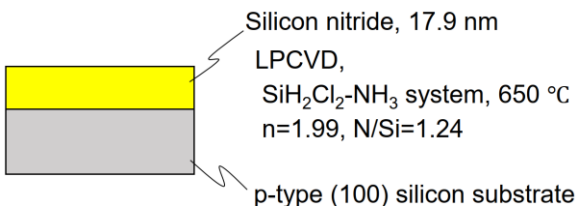

Fig. 2 Schematic cross-section of the sample structure.

ESCO, Ltd.
URL: https://escotds.com/index.html/
E-mail: measurement@escoltd.co.jp
TEL: +81-0422-55-1011
JTEC CORPORATION GROUP

2. Results

Trace (a) in Fig. 3 shows the H_2 desorption spectrum obtained from sample A. Three different peaks of the H_2 desorption rate appeared at 450, 570, and 980 °C.

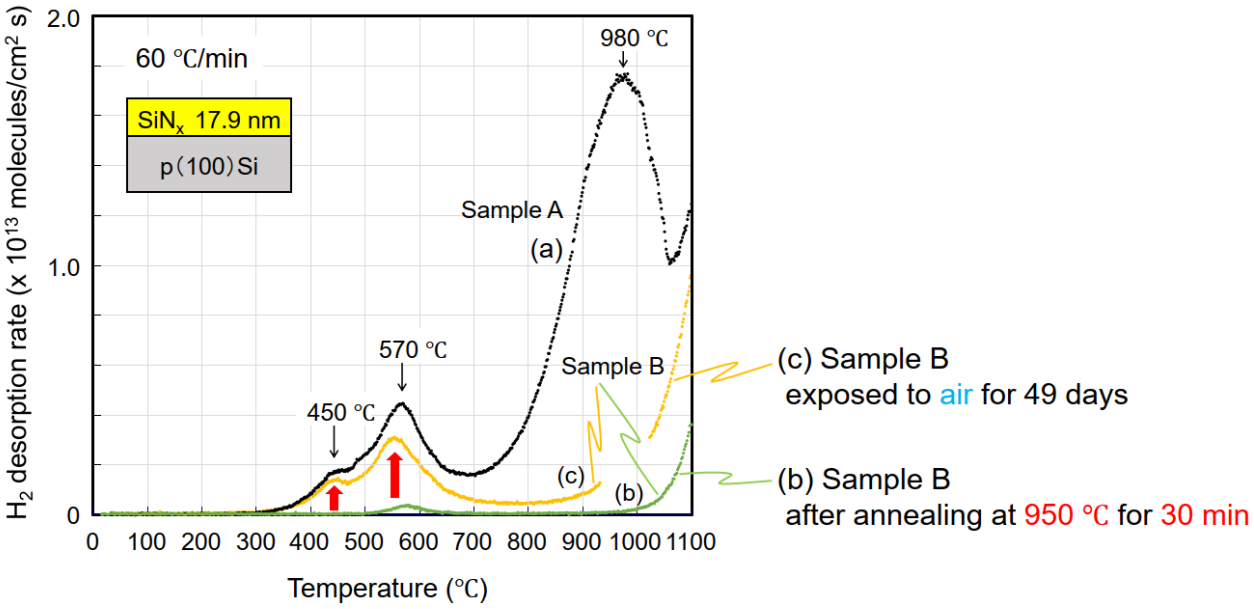

Fig. 3 TDS spectra of H_2 molecules obtained from samples A and B.

Sample B was annealed under ultrahigh vacuum (<1×10^{-7} Pa) at 950 °C for 30 min. As shown in Fig. 3, trace (b) of sample B indicates that the three peaks of the H_2 desorption rate were significantly attenuated. Almost H atoms were released from sample B during the annealing. Subsequently, sample B was exposed to air for 49 days at room temperature and the TDS measurement was conducted again. As seen from trace (c), the two peaks at 450 and 570 °C clearly appeared again.

This result suggests that the two peaks are mainly caused by H_2O or H_2 adsorbed on the native oxides existing on the surfaces of the SiN_x film and Si substrate.

On the other hand, the peak at 980 °C did not recover after air exposure. This indicates that the peak at 980 °C was caused by hydrogen released from the SiN_x bulk, which would be originated with H atoms dissociated from N-H and Si-H bonds in the film, according to Ref. [1].

3. Interpretation

Low-temperature regime (450 °C and 570 °C) — Surface-origin desorption

High-temperature regime (around 980 °C) — Bulk-bonded hydrogen in SiN_x

For further details regarding the above report, please refer to the following reference [2].

ESCO, Ltd.
URL: https://escotds.com/index.html/
E-mail: measurement@escoltd.co.jp
TEL: +81-0422-55-1011
JTEC CORPORATION GROUP

Thermal desorption spectroscopy (TDS) is effective for probing thermally activated processes in thin films such as SiN_x. By separating and detecting surface-origin and bulk-origin species, it enables precise evaluation of the diverse films employed in semiconductor devices.

References

[1] K. Kobayashi, R. Miyauchi, and K. Kimoto, “Influence of high-temperature thermal annealing on paramagnetic point defects in silicon-rich silicon nitride films formed in a single-wafer-type low-pressure chemical vapor deposition reactor,” J. Vac. Sci. Technol. A, vol. 42, pp. 050402-1 - 050402-6, July 2024. https://doi.org/10.1116/6.0003778.

[2] K. Kobayashi and K. Kimoto, "Characterization of Hydrogen Desorption and Charge Traps in Silicon Nitride Films," 2024 International Symposium on Semiconductor Manufacturing (ISSM), Tokyo, Japan, 2024, pp. 1-4, doi: 10.1109/ISSM64832.2024.10874887.