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Hydrogen Desorption under an Anneal-like Temperature Profile in SiN_x Thin Films using ESCO-TDS1200II IR

Semiconductor device fabrication frequently includes isothermal anneal steps. Using thermal desorption spectroscopy (TDS), the desorption behavior of hydrogen during both the temperature ramp and the isothermal hold can be characterized. This note presents a representative example.

Summary

Hydrogen release from SiN_x thin films was measured using the infrared-heating thermal desorption analyzer ESCO-TDS1200II IR under a program similar to a common annealing furnace profile: a 10 °C/min ramp to 950 °C, followed by a 30-minute isothermal hold, as shown in Fig. 1. Three H_2 peaks appeared during heating, and the H_2 desorption rate decreased monotonically during the hold.

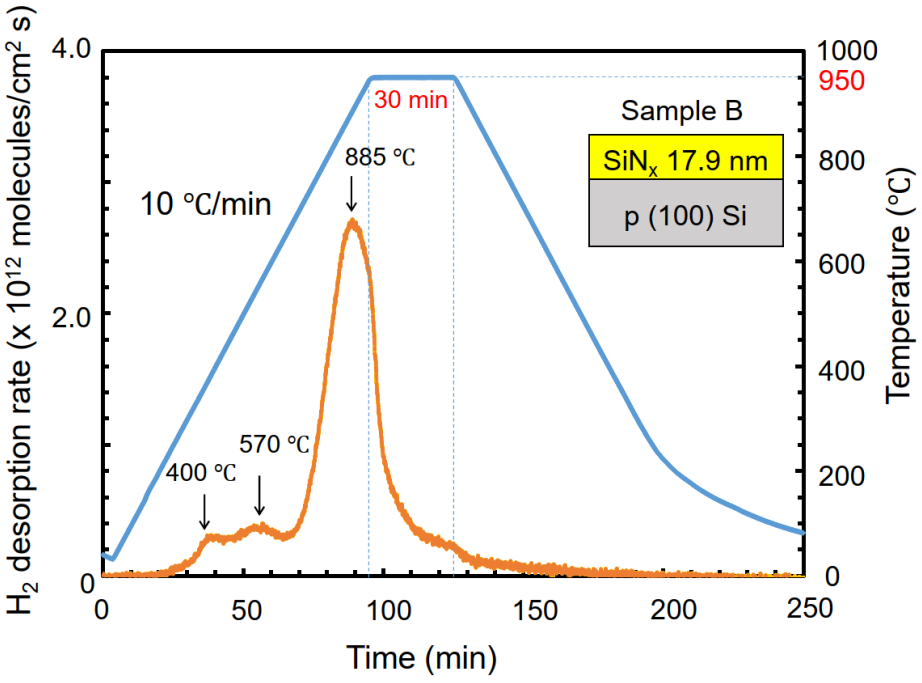

Fig. 1 During the heating segment, three well-resolved H_2-desorption peaks emerged as the temperature increased. During the isothermal segment at 950 °C, the H_2-desorption rate decayed smoothly and monotonically with time.

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

The total released amount was 2.6×10^{21} cm^{-3} on a film-volume basis; 1.7×10^{21} cm^{-3} was released during the ramp (700–950 °C), corresponding to approximately 65% of the total. Using TDS, we observed the desorption behavior of hydrogen during both the temperature ramp and the isothermal hold under this anneal-like program.

Detailed Description

As shown in Fig. 2, a SiN_x film (17.9 nm) was grown on p-type (100) silicon substrates by LPCVD using the SiH_2Cl_2–NH_3 system at 650 °C. In Fig. 1, the left vertical axis shows the H_2 desorption rate, the right vertical axis shows the sample temperature, and the horizontal axis indicates elapsed time. The temperature program of TDS measurement consisted of a linear ramp of 10 °C/min up to 950 °C and a subsequent isothermal hold of 30 min at 950 °C. Measurements were conducted in ultra-high vacuum. Quadrupole mass spectrometry recorded the H_2 signal at m/z 2, while infrared heating provided the programmed temperature profile.

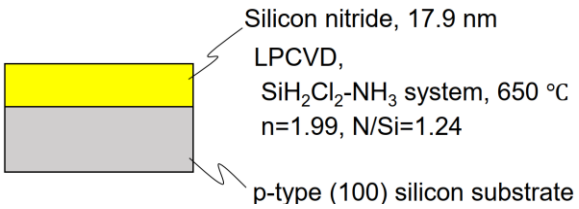

Fig. 2 Schematic cross-section of the sample.

During the heating segment, three well-resolved H_2-desorption peaks emerged as the temperature increased, consistent with the multi-peak structure reported in Application Note 20251114v5. During the isothermal segment at 950 °C, the H_2-desorption rate decayed smoothly and monotonically with time. Integration over the full program yields 2.6×10^{21} cm^{-3} on the adopted film-volume basis, whereas integration restricted to the heating segment (700–950 °C during the ramp) gives 1.7×10^{21} cm^{-3}, which is roughly 65% of the total.

Interpretation

- Ramp (700–950 °C): About 65% of H_2 is released; the three peaks indicate hydrogen from different binding states that begin to desorb as temperature rises.
- Isothermal hold (950 °C): The H_2-desorption rate falls steadily, consistent with release governed by depletion of the remaining bonded hydrogen.
- Process implication: Set the anneal near 900–950 °C and tune hold time (and, if needed, ramp endpoint/rate) to balance throughput vs residual hydrogen.