SiN_x PECVD Technology without Using Explosive SiH_4 Gas

Samco R&D Dept.

■ Introduction

Although SiH_4 (silane) gas is widely used in the semiconductor manufacturing industry to deposit thin films, its potential to detonate poses significant health and safety hazards. In fact, just 0.45 kg of SiH_4 gas has the same explosive power as 2.7 kg of TNT. [1)]

For a safer, easier-to-handle alternative to SiH_4 gas, Samco developed a proprietary CVD method that instead utilizes a liquid precursor, also known as Liquid Source Plasma CVD (LS-CVD).

Although TEOS is well-known as a liquid source for SiO_2, liquid sources for SiN_x plasma deposition are not common. In this technical report, we introduce a newly-developed liquid source called SN-2 (named by Samco), and review its basic properties within two types of plasma-enhanced CVD applications, namely anode type and cathode type.

■ About SN-2

SN-2 is a liquid source with a vapor pressure of 420hPa at 25°C. Although it is flammable, SN-2 differs from SiH_4 gas because it is not pyrophoric and will therefore not spontaneously combust. For gas abatement, a dry absorption scrubber can be used. SN-2 and N_2 are the only gasses needed for basic SiN_x deposition; however, adding NH_3 can lead to easier refractive index adjustments and improved refractive index uniformity.

■ SN-2 Based SiNx Deposition with Anode Coupled PECVD (Model: PD-220NL)

Figure 1 illustrates the PD-220NL's exterior. An external unit that supplies SN-2 is to the system's side. Figure 2 shows an FTIR spectrum of SN-2/SiN_x deposition performed by the PD-220NL. For comparison, the results for SiH_4/SiN_x deposition are also shown.

< SN-2 supply unit > < System body >

Figure 1 PD-220NL Exterior

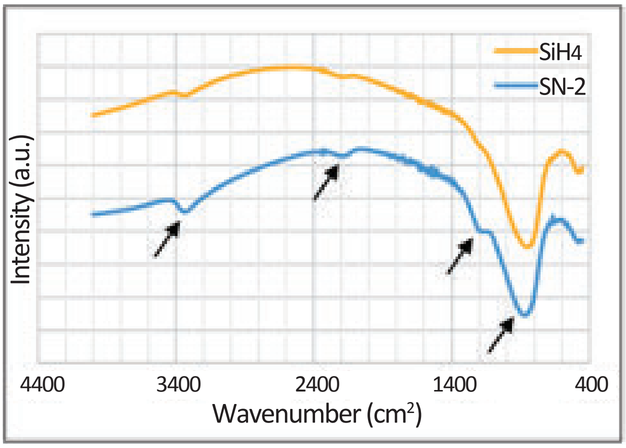

Figure 2 FTIR evaluation of each SiN_x film

In SN-2/SiN_x film, peaks originating from hydrogen such as N-H wagging mode (~1200cm-1), Si-H stretching mode (2160cm-1) and N-H stretching mode

(3350cm^{-1}) are more clearly observed than in SiH_4/SiN_x film. This indicates that the chemical composition of SN-2/SiN_x has a higher amount of hydrogen than SiH_4/SiN_x film.

Figure 3 and Table 1 respectively show a cross-section SEM of deposition performed over Al wires and evaluation results for step coverage. We defined step coverage as the SiN_x film thickness divided by the film thickness at the top surface.

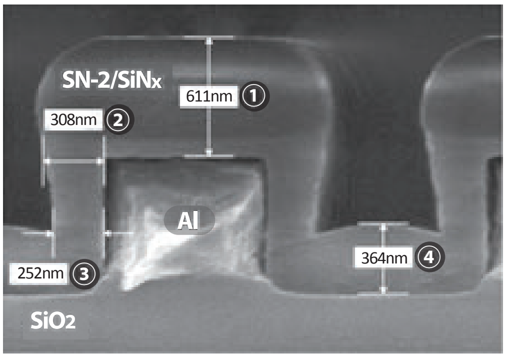

Figure 3 SN-2/SiN_x film deposition over Al wire

Evaluated Area	Step Coverage (%)
① Top	100
② Upper side	50
③ Lower side	41
④ Bottom	60

Table 1 Step coverage

The deposition over the Al wires had a favorable step coverage of more than 40%. Figure 4 shows the film stress control as a function of N_2 flow rate of the PD-220NL using SN-2, NH_3 and N_2 gases. The film stress changed almost linearly from compressive to tensile based on the N_2 flow rate.

This trend of SN-2/SiN_x film stress controllability is similar to that of SiH_4/SiN_x film. Currently, Samco is evaluating device samples for passivation and insulator properties, with these favorable results.

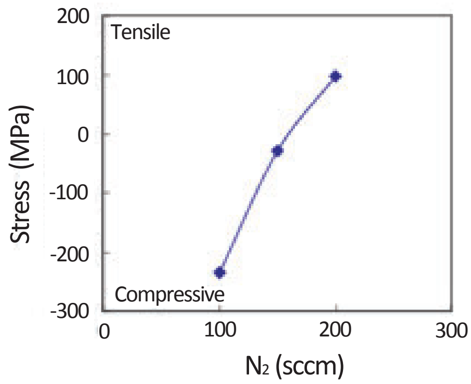

Figure 4 SN-2/SiN_x film stress controllability based on N_2 gas flow

■ SN-2 Based SiN_x Deposition with Cathode Coupled PECVD

We are now developing SN-2/SiN_x for another deposition method, namely cathode coupled plasma CVD. This method actively utilizes ion bombardment for film deposition, which makes it easier to deposit dense film. Depending on the process requirements for the samples' temperature stability, deposition is possible at temperatures ranging from room temperature to 400°C, with film stress control ranging from almost zero to more than 1 GPa.

■ Conclusion

SN-2/SiN_x deposition using anode coupled plasma CVD clearly produces film that contains a higher amount of hydrogen than that of SiH4/SiN_x deposition. A step coverage of 40% and a wide range of stress controllability from -300MPa (compressive) to +100MPa (tensile) are also confirmed.

The application of SN-2 to cathode coupled plasma is currently under investigation.
With those processes, we are in the process of uncovering new applications, such as optical waveguides, MEMS and organic device passivation films. Going forward, we will continue to develop new applications and provide systems for our customers.

■ Reference

1) Fischman, Michael L. "Semiconductor Manufacturing Hazards." *Clinical Environmental Health and Toxic Exposures.* By Gary R. Krieger and John Burke. Sullivan. Philadelphia, Pa.: Lippincott Williams & Wilkins, 2001. N. pag. Print.

Contact Information

- **Email**: info@samco.co.jp
- **Phone:** +81(0)75-621-7841 (Headquarters)

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