Silicon Nitride Etch Process

Electronic-grade silicon nitride films are formed using chemical vapor deposition (CVD), or one of its variants, such as plasma-enhanced chemical vapor deposition (PECVD):

\[
\begin{align*}
3 \text{SiH}_4(g) + 4 \text{NH}_3(g) & \rightarrow \text{Si}_3\text{N}_4(s) + 12 \text{H}_2(g) \\
3 \text{SiCl}_4(g) + 4 \text{NH}_3(g) & \rightarrow \text{Si}_3\text{N}_4(s) + 12 \text{HCl}(g) \\
3 \text{SiCl}_2\text{H}_2(g) + 4 \text{NH}_3(g) & \rightarrow \text{Si}_3\text{N}_4(s) + 6 \text{HCl}(g) + 6 \text{H}_2(g)
\end{align*}
\]

For deposition of silicon nitride layers on semiconductor (usually silicon) substrates, two methods are used:

1. Low pressure chemical vapor deposition (LPCVD) technology, which works at rather high temperature and is done either in a vertical or in a horizontal tube furnace, or
2. Plasma-enhanced chemical vapor deposition (PECVD) technology, which works at rather low temperature and vacuum conditions.

In a research application, to facilitate a Nitride tool you will need gas cabinets to safely house and deliver the process gases, and an abatement unit to destroy the waste gases after leaving the tool.

**Typical Flow Rates:**

- < 1 SLPM SiH4
- <1 SLPM NH3
- 20 – 30 SLPM N2

**Research / Production Tools:**
- Plasmatherm Versaline
- Oxford PlasmaPro
- Novellus Concept One

**Facilitation Information:**

**Silane (SiH4):**
- Classification: Pyrophoric in concentrations higher than 1.37%
- Gas Cabinet with ESO Capability - Required, Must Comply with CGA Code G-13
- Pressurized Gas
- DISS 632 Connection Recommended
- Coax Tubing is Recommended but not required by Code
- Purge Gas of Helium/Nitrogen blend is recommended
- Hazardous Gas Monitor for Gas Supply Shutdown - Required

**Ammonia (NH3):**
- Classification: Flammable, Toxic
- Gas Cabinet with ESO Capability - Required
- Liquefied Gas
- DISS 720 Connection Recommended
- Single Containment Tubing is Permitted by Code
- Purge Gas of Helium/Nitrogen blend is recommended
- Purge Gas Purifier Strongly Recommended

**Gas Scrubber:**
- Required
- Type Suggested: Resin Bed Scrubber – Novapure EGS237 - A 37 gallon dry resin single canister point of use scrubber capable of abating SiH4 and NH3 gases in the flow rates shown.
- Duty Cycle – 100%
- Canister – Disposable/Replaceable, hazardous gas is converted to non-volatile solids
- Monitoring – Outlet of scrubber should be sent to facility scrubber or monitored for shutdown and exhausted in a safe area

**Note:** CSI always recommends enlisting a professional engineer to determine the Codes your facility will be required to meet for your installation. CSI's information above is for informational purposes only and not intended to serve as a statement of what is legally required to meet local and national compliance.