MODUTEK CORPORATION

Nb SERIES THEORY OF OPERATION
PROCESS CONTROL

1.0 The silicon nitride etch operates in a boiling solution which is a combination 85% phosphoric acid (H_3PO_4) and 15% DI water and boils at around 160°C. At this temperature, the water in the solution boils off as steam. Our Nb Series MODUBATHS^R, which are designed for silicon nitride etching, include a refluxor (cooling condenser) to condense some of the steam back to water to maintain the solution concentration. However condensers are not 100% efficient, so it is required that water periodically be added to the solution.

For safety reasons, basic chemistry rules generally discourage adding water to acid. However, the needs of this process require that this be done. We have found that there are ways of doing this safely. If the acid is rapidly agitated or boiling, then slowly adding small amounts of water mixes right away and poses no safety problems. However, if water is added to non-boiling acid, especially a viscous acid (like H_3PO_4), the water tends to sit on top of the acid. The acid still needs water, so more is added. This results in a layer of water on top of the acid. When enough heat is absorbed by the water to boil it, all the water mixes with the acid at once, and a reaction occurs.

Another key to enhancing the safety of this process is to remember the real objective of adding water. The real objective is to maintain a uniform concentration of H_3PO_4 at the required temperature. Water is not being added to cool the acid. As the nitride etch solution loses water its boiling point increases and when water is added its boiling point decreases. Therefore, we can use temperature as an indication of concentration and when to add water. But, it is not temperature itself that we are trying to control.

Another way that safety is enhanced, and the chance of having an explosion is diminished, is to adhere to a basic chemistry rule: “The temperature of a solution cannot rise above its boiling point, except under special circumstances”. Therefore, it is not necessary to control the heater on our system. Whenever the heater switch is on, the heater is on, regardless of what the temperature controller says. By not regulating the heater, we can heat the solution to boiling regardless of the concentration, and keep it boiling while we add water to adjust the concentration. The temperature controller only determines when to add water, which is still at the upper set point.

There are also several interlocks built into the system for safety, reliability, and to protect the equipment. To be certain that we do not add water without the

solution boiling, there is a boil interlock. A thermocouple is positioned above the surface of the tank and connected to an interlock board, which shuts off power to the water-add solenoid valve if the air above the solution is not filled with hot steam. A boil indicator light on the control panel shows the status of that interlock and will be on whenever the solution is boiling. The interlock will reset itself once the solution comes to a boil. This interlock is calibrated to trip within 30 minutes if the lid is off because, when open, the tank loses water and heat rapidly to the air and can stop boiling, even with the heaters on. There are two thermocouples in the back corners inside the tank. One is the water-add thermocouple connected to the controller, as mentioned above, and the other is for the bath overtemperature interlock. This interlock shuts off the heaters if the bath temperature rises above 170°C. If this interlock trips, it is an indication of something wrong with the water-add, the calibrations, or the acid solution itself. The last interlock is the tank overtemperature interlock, which protects the tank from overheating if turned on with no solution in the tank. The thermocouple is on the outside of the quartz and next to the heater elements. The tank overtemperature interlocks are controlled by the same dual-channel interlock board. If either interlock is tripped, a red overtemperature reset lamp lights up and must be pressed to override the interlock after the problem has been corrected.

In addition to the change in process philosophy, the Nb Series incorporate the following features:

Safety Features

- Flame retardant, polypropylene, UL94-VO rated.
- Integral snap switch (curtails power to the process controller / timer if the process solution temperature exceeds 205°C ± 10°C).

Process Enhancement

- Teflon refluxor.
- Heavy-duty, three-way solenoid (bleeds off DI water when not in use and eliminates “dead legs” where bacteria could grow).
- Precise DI metering valve with pressure indicator.

Convenience/Longevity

- Process hardware (DI city water solenoid, metering valve, etc.) enclosure
- Clearly labeled hook-up panel

2.0 ENHANCED PROCESS CONTROLLER/TIMER (PCT)

Outstanding Features

- Multiple diagnostic/set-up functions
- Integrated count down/thru timer with pre-warn alarm
- Independent, high limit (overtemperature) shut off
- Tamper resistant, programmable access code
- Acid/solvent resistant keypad
- Alarm silence key
- Four (4) type J thermocouple connections
- EEPROM memory (minimum 10 year life, no battery back-up required)
- One year warranty

Primary Mode Status Indicators

- Operation (normal)
- Alarm warning
- Heat (power on)
- DI injection
- Program (review)

3.0 ALARM STATUS INDICATORS (VISUAL, AUDIBLE)

- System, sensor malfunction
- High limit (system temperature)
- High, low process temperature
- Low liquid level
- Pre-alarm time setting
- Zero count “0:00”, count up
- Boiling limit