Specifications for LPCVD Furnace Gas Distribution System

The Naval Research Laboratory, Washington DC, 20375 (NRL-DC) requires a gas distribution system to implement growth of low-pressure chemical vapor deposition (LPCVD) silicon nitride, polysilicon, and wet-oxidation of silicon to form silicon dioxide. To support these operations the system must deliver dichlorosilane (SiH_2Cl_2), silane (SiH_4), ammonia (NH_3), oxygen (O_2) and nitrogen (N_2) gases from bottles stored in gas storage cabinets to an LPCVD/wet-ox furnace system. Offerors must provide pricing on all items within a section and/or all sections. A single offeror may provide pricing for all of Sections 1, 2 and 3. Section 1 provides for the gas cabinets, process and purge panels, gas regulators, toxic gas sensors, and controls for automatic shutdown of toxic gases. Section 2 provides for the single and double-wall stainless steel tubing, labor, and all weldments, fittings and attachments to connect the gas bottles to the LPCVD deposition system. Section 3 provides for the optional furnace exhaust kit including the heated foreline tube and transformer to be used in the exhaust of gases from this system. The contractor(s) must provide complete system installation and conduct operational testing. The contractor(s) must provide a standard commercial warranty for all parts and labor. Delivery and acceptance is at NRL-DC, FOB Destination.

Abbreviations

CGA	Compressed Gas Association
DCS	Dichlorosilane, SiH_2Cl_2
psi	Pounds per square inch
psig	Pounds per square inch, gauge
SEMI	Semiconductor Equipment and Materials International
SLPM	Standard liters per minute

Section 1. Gas handling equipment

Process gases. The gas handling equipment must be capable of safe handling of the following gases at 100% concentration:

a. Dichlorosilane; Electronic grade; Cylinder size #3; CGA valve type 678.
b. Silane (SiH_4); Electronic grade; Cylinder size #2; CGA valve type 350.
c. Ammonia (NH_3); 99.999% purity; Cylinder size #2; CGA valve type 660SS.
d. Oxygen (O_2); 99.997% or greater purity; Cylinder size #1; CGA valve outlet 540.
e. Nitrogen (N_2); 99.9995% or greater purity; Cylinder size #1; CGA valve outlet 580.

The contractor must provide 3 gas cylinders of N_2 to allow automatic N_2 purge of the toxic gas lines.

1.1 **Toxic gas bottle cabinets**. The contractor must provide three dual gas bottle cabinets to safely store the gases itemized in (a) – (c). Dichlorosilane, silane, and ammonia are considered toxic and will each be stored in separate cabinets with one bottle of nitrogen gas each. All toxic gas bottle cabinets must be outfitted with sensors capable of detecting gas leaks and performing

automatic closure of gas bottles upon detection of a leak. The cabinets must allow connection of ductwork to be attached to NRL-supplied exhaust lines for continuous ventilation of the cabinet.

1.2 **Automated gas process panel, DCS.** The contractor must supply an automated process panel for control of valving and process pressure for dichlorosilane. The process panel must be of an 'all-welded' design. Automated operation is to be via an electronic and/or pneumatic interface to minimize operation of process controls within the gas cabinet. The process panel must be capable of automatic shutdown upon activation of a control signal from a sensor/shutdown control unit. The process panel is to be mounted within the gas bottle cabinet and will connect to the gas cylinder and must provide pressure regulation within the range 5 – 30 psi (minimum) at a flow of 0.1 SLPM (maximum).

1.3 **Automated gas process panel, silane.** The contractor must provide an automated process panel for control of valving and process pressure for silane. The process panel must be of an 'all-welded' design. Automated operation is to be via an electronic and/or pneumatic interface to minimize operation of process controls within the gas cabinet. The process panel must be capable of automatic shutdown upon activation of a control signal from a sensor/shutdown control unit. The contractor will mount the process panel within the gas bottle cabinet and will connect to the gas cylinder and must provide pressure regulation within the range 5 – 30 psi (minimum) at a flow of 0.2 SLPM (maximum).

1.4 **Option I. Automated gas process panel, ammonia.** The contractor must provide an automated process panel for control of valving and process pressure for ammonia. The process panel must be of an 'all-welded' design. Automated operation is to be via an electronic and/or pneumatic interface to minimize operation of process controls within the gas cabinet. The process panel must be capable of automatic shutdown upon activation of a control signal from a sensor/shutdown control unit. The contractor will mount the process panel within the gas bottle cabinet and will connect to the gas cylinder and must provide pressure regulation within the range 5 – 30 psi (minimum) at a flow of 0.2 SLPM (maximum).

1.5 **Option II. Manual gas process panel, ammonia.** The contractor must provide a manual process panel for control of valving and process pressure for ammonia. The process panel must be of an 'all-welded' design. The process panel must be capable of automatic shutdown upon activation of a control signal from a sensor/shutdown control unit. The contractor must mount the process panel within the gas bottle cabinet and will connect to the gas cylinder and must provide pressure regulation within the range 5 – 30 psi (minimum) at a flow of 0.2 SLPM (maximum).

1.6 **Automated purge panel, DCS.** The contractor must provide an automatic purge panel to allow remote nitrogen purge of dichlorosilane gas lines. The purge panel is to be mounted within the gas bottle cabinet and of an 'all-welded' design. Electronic and/or pneumatic interface is required to minimize operation of controls within the gas cabinet.

1.7 **Automated purge panel, silane.** The contractor must provide an automatic purge panel to allow remote nitrogen purge of silane gas lines. The purge panel is to be mounted within the gas bottle cabinet and of an 'all-welded' design. Electronic and/or pneumatic interface is required to minimize operation of controls within the gas cabinet.

1.8 **Option III. Automated purge panel, ammonia.** The contractor must provide an automatic purge panel to allow remote nitrogen purge of ammonia gas lines. The purge panel is to be mounted within the gas bottle cabinet and of an 'all-welded' design. Electronic and/or pneumatic interface is required to minimize operation of controls within the gas cabinet.

1.9 **Option IV. Manual purge panel, ammonia.** The contractor must provide a manual purge panel to allow remote nitrogen purge of ammonia gas lines. The purge panel is to be mounted within the gas bottle cabinet and of an 'all-welded' design.

1.10 **Toxic gas sensors and shutoff control, dichlorosilane.** The contractor must provide a dual-channel sensor unit for detection of dichlorosilane. One sensor is to be mounted in the gas cabinet and the second sensor is to be mounted within the gas panel of the LPCVD furnace system. The contractor must provide up to 40' of wire to interface the furnace-mounted sensor to the shutoff control unit. The sensor unit/shutoff control system must provide automatic shutdown of primary gas valves for the dichlorosilane process panel at a concentration of 5 ppm or greater at either of the two sensor locations.

1.11 **Toxic gas sensors and shutoff control, silane.** The contractor must provide a dual-channel sensor unit for detection of silane. One sensor is to be mounted in the gas cabinet and the second sensor is to be mounted within the gas panel of the LPCVD furnace system. The vendor must provide up to 40' of wire to interface the furnace-mounted sensor to the shutoff control unit. The sensor unit/shutoff control system must provide automatic shutdown of primary gas valves for the silane process panel at a concentration of 8 ppm or greater at either of the two sensor locations.

1.12 **Toxic gas sensors and shutoff control, ammonia.** The contractor must provide a dual-channel sensor unit for detection of ammonia. One sensor is to be mounted in the gas cabinet and the second sensor is to be mounted within the gas panel of the LPCVD furnace system. The contractor must provide up to 40' of wire to interface the furnace-mounted sensor to the shutoff control unit. The sensor unit/shutoff control system must provide automatic shutdown of primary gas valves for the ammonia process panel at a concentration of 35 ppm at either of the two sensor locations.

1.13 **Non-toxic gas bottle cabinet**. The contractor must provide one dual gas bottle cabinet for the storage of process nitrogen and oxygen gas cylinders itemized in (d) and (e) above.

1.14 **Oxygen gas regulator**. The contractor must provide two (2) each of CGA type 540 gas regulator for oxygen service. The gas regulator must provide gauge readouts of bottle pressure and regulator output pressure and a diaphragm shutoff valve. The regulator must be capable of operation at 5 – 30 psig (minimum) at a gas flow of 10 SLPM (maximum). Output fittings must be ¼" male VCR.

1.15 **Option V. Oxygen gas regulator**. The contractor must provide one additional oxygen gas regulator as described in 1.14.

1.16 **Nitrogen gas regulator**. The contractor must provide four (4) each of CGA type 580 regulator for nitrogen service. The gas regulator must provide gauge readouts of bottle pressure and regulator output pressure and a diaphragm shutoff valve. The regulator must be capable of operation at 5 – 30 psig (minimum) at a gas flow of 25 SLPM (maximum). Output fittings must be ¼" VCR.

1.17 **Option VI**. **Nitrogen gas regulator.** The contractor must provide one (1) additional nitrogen gas regulator as described in 1.16.

1.18 **Operating manuals**. Operating manuals describing the operation of all components of the gas handling equipment must be provided.

1.19 **Option VII.** The contractor must provide one bottle of items (a) and (b) listed above. The cost will include purchase of the cylinder and associated gas. (No gas bottle rental and/or demurrage.)

1.20 **Option VIII.** The contractor must provide two bottles each of items items (c), (d) and (e) listed above. The cost will include purchase of the cylinder and associated gas. (No gas bottle rental and/or demurrage.)

1.21 **Option IX. Ammonia gas regulator**. The contractor must provide one (1) each of CGA type 660 stainless steel regulator. The gas regulator must provide gauge readouts of bottle pressure and regulator output pressure and a diaphragm shutoff valve. Output fittings must be ¼" VCR.

1.22 **Option X.** The contractor must provide installation at NRL-DC of the items in Section 1. (Does not include the installation of stainless steel gas lines. These are to be installed per Section 2 below.)

Section 2. Gas line installation.

Refer to Figures 1 and 2 for a schematic diagram of the connections required between the process gas cabinets and the LPCVD/wet-ox furnace system.

2.1 **Coaxial stainless steel gas lines**. The vendor is to provide connection of three process gases dichlorosilane, silane, and ammonia to the LPCVD furnace system using separate, coaxial stainless steel gas lines. The inner tube will transmit the process gas and is to be ¼" electropolished stainless steel equal to or better than Valex Corporation 401 (SP-9220 specification). The outer tube must be constructed of 316 stainless steel and is to be connected to an NRL-provided nitrogen gas supply for continuous purge. The outer tube of each line must be equipped with a purge tee at both the gas cabinet end and the LPCVD furnace end for nitrogen purge. The outer coaxial tube is to fully enclose the inner process gas tube between the gas cabinets and the LPCVD furnace system. The inner process line must withstand a 24-hour static pressure test at 200 psi (minimum) internal pressure with no greater than 2 psi pressure loss. Attachment to the LPCVD furnace system must accommodate welds performed within the LPCVD gas panel having internal dimensions 17" wide x 17" deep x 23" high. The vendor should follow the diagram of Figure 1 with direction from the contracting officer's technical representative during installation.

2.2 **Single-wall stainless steel gas lines**. The vendor is to provide connection of oxygen and nitrogen process gases from the gas cabinet to the LPCVD furnace system. The tubing will transmit the process gas and is to be ¼" electropolished stainless steel equal to or better than Valex Corporation 401 (SP-9220 specification). The vendor should follow the diagram of Figure 1 with direction from the contracting officer's technical representative during installation. The vendor must provide ¼" female VCR fittings at both the gas cabinet end and furnace end of the tubing. The process lines must withstand a 24-hour static pressure test at 200 psi (minimum) internal pressure with no greater than 2 psi pressure loss.

2.3 **VCR fittings attachment for oxygen, nitrogen**. The vendor is to provide ¼" male VCR welded fittings to ¼" stainless steel stubs at the LPCVD nitride furnace.

2.4 **Finish requirements**. All process gas tubing must have a surface finish roughness (R_a) of 10 micrometers or less.

2.5 **Weld standards**. All welds to the system must be fully penetrated and meet SEMI Standard F78-0703.

Section 3. Option XI. Furnace Exhaust Kit.

3.1 The contractor must provide a 55 inch heated foreline tube for exhaust of the LPCVD furnace system. The kit must be equivalent to MRL Industries 1000 TBA composed of 55 inch heated foreline with KF 50 connections, 2 each KF 50 centering rings with o-rings and clamps, and MKS self-regulating heater blankets, and power transformer.

3.2 The contractor must provide installation of the heated foreline and transformer system to the government owned MRL Industries LT/HT1012 furnace system located at NRL-DC.

3.3 The foreline tube heater and control must be compatible with operation of the government owned MRL LT/HT1012 furnace system.

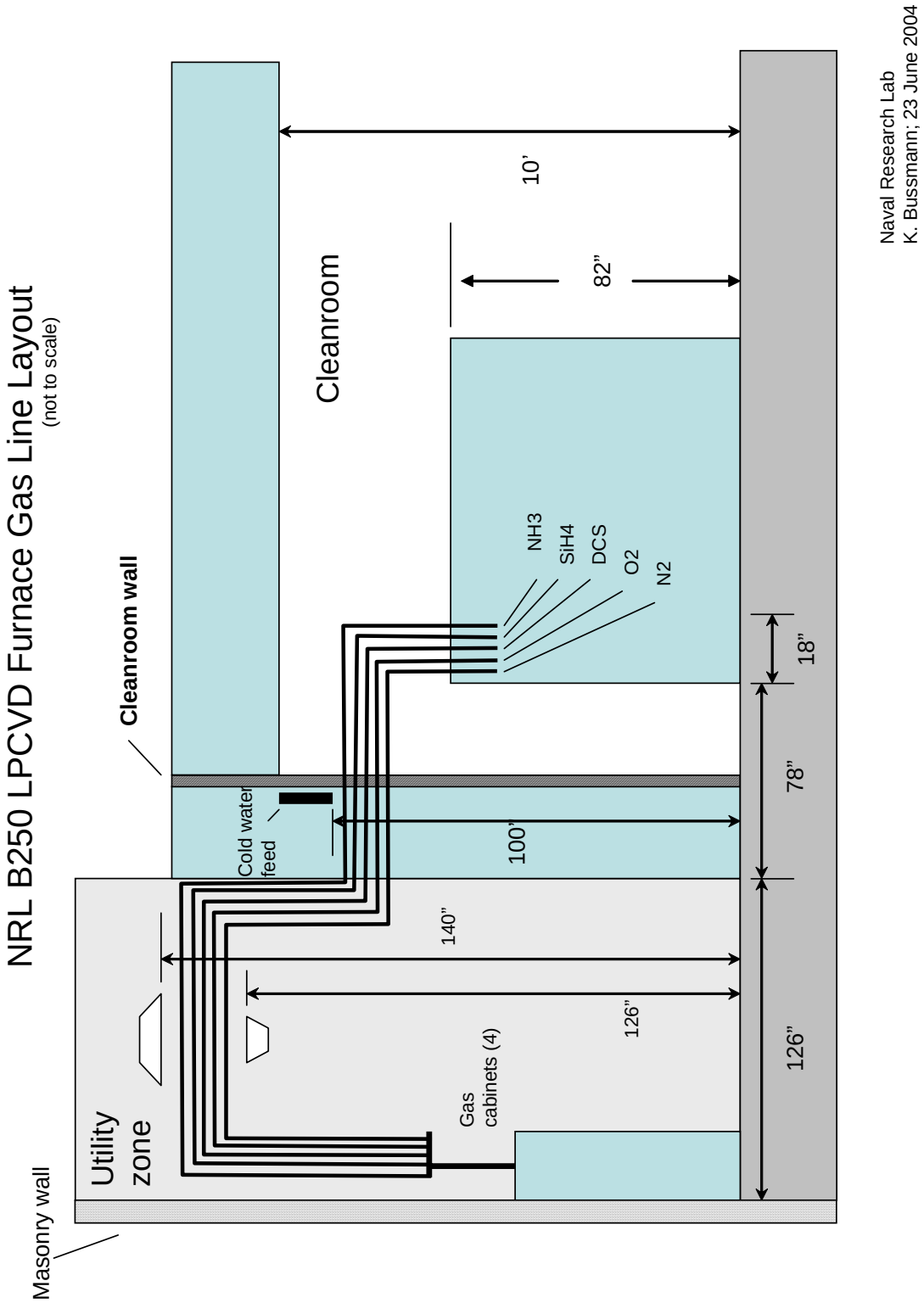

Figure 1. Cross-sectional view of B250 installation area.

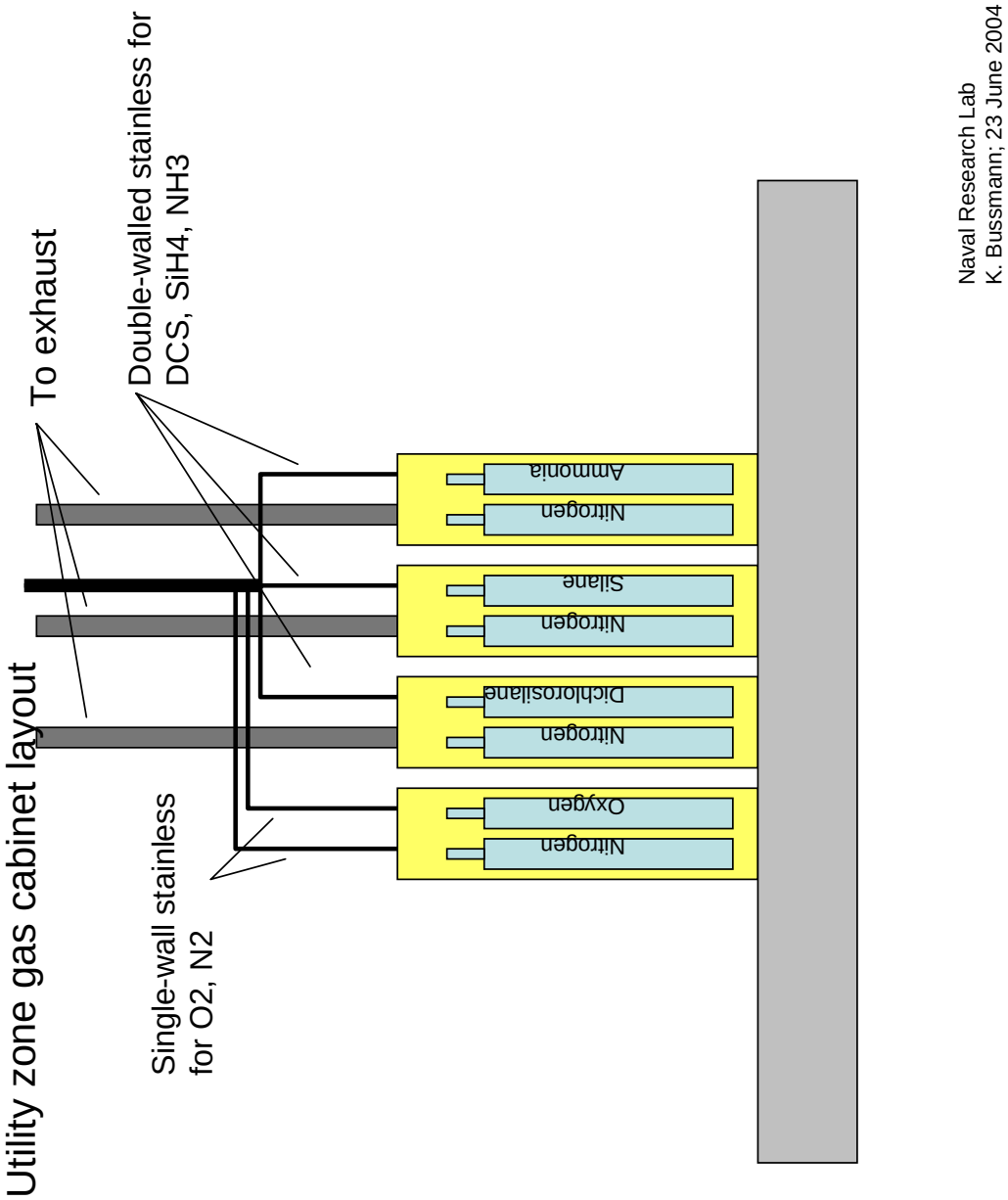

Figure 2. Gas bottle cabinet layout.