Hybrid thin film deposition chamber integrated to existing Riber molecular beam epitaxy system.

We require a thin film material deposition chamber, including sputter guns, and capable of supporting thermal effusion (K-cell) sources, a multipocket e-beam source, ion gun, and several metrology tools. The system will be integrated with an existing Riber Modutrac UHV chamber to allow multilayer film growth in multiple chambers without exposure to atmosphere and will have a separate loadlock to atmosphere. The equipment will be installed in the Epicenter molecular beam epitaxy facility at the Naval Research Laboratory, Washington, DC. The facility has 120 VAC and 208 VAC single and three-phase electrical power, compressed air, compressed dry nitrogen. Used equipment and/or components will not be considered.

1) Chamber
   a) High vacuum stainless steel chamber with base pressure 2.0e-8 Torr or less.
   b) UHV conflat metal seals on ports, except for the main access door/port of the chamber.
   c) Main access door/port will be hinged, or liftable by one person, or a mechanical lifting system will be provided.
   d) Chamber will be designed to accommodate transfer of samples from both a standard loadlock and from a Riber Modutrac UHV system as described in Section 4. The system will provide all transfer and sample mounting hardware to adapt to the Riber 2" Molyblock system.
   e) The chamber, pumping system, and all accessories will be compatible with the use of gallium, selenium and other volatile elements such as tellurium, lead, bismuth, zinc, arsenic, and antimony. Proposals must describe all standard and nonstandard measures taken to achieve this goal.
   f) The chamber will be configured with ports for the following (NOTE: not all the components themselves are required. Required components are described in later sections):
      i) Ports for six magnetron sputtering sources and/or thermal effusion (K-cell) sources in a modular confocal geometry in a deposit-up configuration.
      ii) Port for substrate stage, heater, and associated hardware. A flange mount (min 8") is required for this hardware, so that in the future, a different substrate stage and associated hardware could be mounted in its place with only a minor hardware swap.
      iii) Port for a four-pocket e-beam evaporator with a crucible capacity of at least 8cc each. Active pocket will be located on substrate axis in deposit-up geometry and configured with a pneumatic shutter. The chamber space for the e-beam evaporator will be able to accommodate a normal incidence sputtering gun with short working distance (2-4") when the e-beam system is not installed.
      iv) Port for ion source, positioned appropriately for uniform coverage of a 4" substrate with rotation.
      v) Ports for all required vacuum gauges, gas handling, electrical connections.
      vi) Ports for reflection high energy electron diffraction (RHEED), including both a gun and a phosphor screen (6" port). Positioning will be balanced to magnetron sputtering guns to

minimize beam deflection. The system will be able to accommodate future differential pumping for the RHEED gun and shutter for phosphor screen.

vii) Ports for optical (bandgap) thermometry in reflection and transmission geometry (e.g. kSA Bandit).

viii) Ports for ellipsometry

ix) Port for residual gas analyzer with differential pumping.

x) Port (10" conflat) positioned to permit future connection and sample transfer to another deposition chamber of comparable size at a future date. The same port would also be appropriate for installation of a cryopump or liquid nitrogen trap appropriate for collecting volatile material during system baking.

g) Shuttered viewports to allow line of sight viewing of the sample stage, appropriate for loading from both the loadlock and the Riber system. The sample stage will be viewable during deposition. If ambient light is not sufficient to view sample transfer, an integrated chamber light will be included. Viewports will also allow viewing of sputtering guns and active ebeam pocket.

h) The total available footprint is 40 inches by 9 feet. The long axis of the footprint begins at the mating flange to the Riber system but does not include the transfer arm from the Riber system, because that will be on the other side of the Riber system.

i) Chamber liners to minimize direct deposition on chamber walls.

j) Chamber and all components will be bakeable to 200C, with the exception that the o-ring on the main access/door port should be bakeable to 150C.

2) System vacuum

a) A magnetically levitated turbo pump with at least 2000L/s pumping speed to achieve base pressures of 2.0 e-8 Torr or better.

b) Turbo pumps will have dry backing pumps.

c) A baffle cooled with liquid nitrogen or cold water will be included to limit the introduction of high vapor pressure materials into the turbo pump.

d) Chamber will have vacuum gauges covering the range from atmosphere to base pressure, and capable of operation during deposition.

e) Throttle valve between turbo and chamber for downstream pressure control during gas processes (See section "Gas Handling").

f) A gate valve between the load lock and main chamber to allow for continuous pumping when unloading and loading samples.

g) A nitrogen purge line for venting. A computer-controlled venting procedure will be incorporated for safe venting of the main vacuum chamber and (separately) safe spin-down of the turbo pump. A manual vent port and valve are to be included.

3) Loadlock chamber for sample introduction from atmosphere

a) Full range vacuum gauge

b) Turbo pump and mechanical vacuum pump separate from main chamber, capable of achieving pressure less than 1e-5 torr within 10 minutes of pumpdown start sequence

c) Automated venting within 5 minutes of start sequence (assumes thermal or ebeam evaporation sources are already cooled)
d) Sample cassette allows simultaneous loading and sequential processing of two samples
e) Manual UHV gate valve separating load lock from main chamber
f) Manual transfer of samples using transfer arm

4) Sample transfer from existing Riber Modutrac
   a) The system will be capable of loading from either the Riber system or the loadlock chamber. Both options will be available simultaneously.
   b) Transfer arm that mounts to the Riber Modutrac
      i) Retrieves Riber 2" Molyblock from Riber substrate Chariot with 3-finger claw design. Molyblock (wafer) begins oriented upright, i.e. perpendicular to floor and coaxial with transfer arm.
      ii) Transfer arm claw will be removable from transfer arm to allow future use of a different mounting mechanism.
   c) A mechanism for reorienting the Molyblock to face down for upward deposition
   d) A 6" manual UHV gate valve to isolate the Riber Modutrac from the deposition chamber and to allow independent venting of one side or the other.

5) Sputtering guns.
   a) Two magnetron sputter guns are to be provided with the system.
   b) Positioned in confocal geometry.
   c) Flat 2 inch circular target geometry, water cooled to dissipate heat but not direct-cooled inside the chamber.
   d) UHV-compatible guns with conflat flange mounting.
   e) Capable of being added or removed from the chamber with appropriate blanking flanges.
   f) Configured with modular magnet arrays allowing for balanced, unbalanced, and magnetic material deposition modes.
   g) Tiltable from outside the chamber while under vacuum.
   h) Bakeable to 200C without disassembly.
   i) All guns are designed to receive direct gas feed via VCR or similar fittings. (Not all gas lines need be connected. See Section "Gas Handling")
   j) Computer-controlled pneumatic shutters
   k) Fully shielded with chimneys to prevent cross-contamination of target materials during co-deposition of thin films from multiple targets and to minimize unwanted deposition in chamber.

6) Sputter gun power supplies.
   a) RF power supply
      i) Includes an automated matching network to minimize reflected RF power to the source
      ii) Minimum power rating of 300W.

b) Pulsed DC power supply
   i) Minimum power rating of 750W.
   ii) Variable frequency of 5-350kHz
   iii) Capable of continuous DC operation
c) Switching system for both RF and pulsed-DC supplies to deliver output to any of up to 4 guns. The supplies are to be configured to allow for co-deposition of a minimum of two separate target materials.
d) System should be upgradable to accept additional sputter gun power supplies within the existing footprint at a future time.

7) Sample stage.
   a) The stage will accommodate a variety of substrate sizes, from small pieces up to 4" circular wafers.
   b) Film thickness uniformity across a 4" wafer for confocal sputtering guns should be within +/- 1.5%.
   c) User-controlled continuous rotation, variable speed. Stage rotation is an acceptable means to achieve required thickness uniformity.
   d) Stage-affiliated hardware that is not easily sand-blasted or otherwise cleaned should be shielded to minimize direct deposition.
   e) Working distance between 4" and 8" for confocal sputtering sources. The stage should have a minimum two inch adjustable working distance. The stage, substrate heater, and gas ring travel together.
   f) The stage is to be electrically isolated from the chamber to allow RF and DC bias capability while rotating, heating, or depositing.
   g) An RF power supply and matching network, separate from the sputter gun RF power supply, are to be included to allow for backsputtering and RF bias during growth.
   h) Halogen lamp substrate heater 50C-800C in vacuum and in presence of 5 mTorr oxygen with +/- 1 degree C temperature stability. Stage temperature will be measured by thermocouple, and will be calibrated by optical pyrometry of the sample holder platen at the installation site.
   i) In situ control of deposition temperature, rotation, and RF back-sputter and bias are to be computer controlled. Temperature is controlled with active feedback on thermocouple. Temperature control system will be compatible with future control feedback using optical (bandgap) thermometry.
   j) A computer-controlled pneumatic sample shutter that operates independent of deposition will be included and is to be operable when deposition occurs from confocal sputter guns
   k) A film thickness sensor should be included in the vicinity of the sample stage to allow for calibration of the deposition rate of any of the guns. The monitor may be mounted on a retractable arm to avoid interference with the substrate during deposition or it may be located on the back of the sample shutter.

l) A film thickness control with active feedback should be integrated with thermal evaporation and e-beam sources to control thickness during deposition from those sources. The sensor should be located in the vicinity of the substrate, where it doesn't interfere with the deposition.

8) Gas handling.
   a) A minimum of three mass flow controllers (MFC) configured for full-scale operation with Ar at 50 sccm, O2 at 20 sccm, N2 at 20 sccm. Needs to be expandable to more reactive gases. All MFC's rated to 1% accuracy of full-scale or less with display resolution of 0.1 sccm or less.
   b) VCR type gas fittings.
   c) Argon and should be plumbed to gas rings at every other (total three) of the six sputter gun ports. Pneumatic isolation valves should be present at these targets, so that gas lines do not need to be pumped out through the chamber after each vent. System and guns should be designed to allow gas to be delivered to all 6 targets in the future.
   d) Oxygen, nitrogen, or other reactive gases will be delivered through a gas ring at the sample stage that moves with the stage.
   e) Automated downstream pressure control by use of throttle valve mounted in front of main turbo pump in combination with capacitance manometer pressure readout. Active pressure control range: 1.0 mTorr - 30 mTorr (minimum) with accuracy and resolution of 0.1 mTorr or less at Ar flow within the range of 1 – 50 sccm.

9) Computer and System Control.
   a) Windows 7 or later operating system.
   b) Integrated control of all sputter gun power sources and switches, K-cell power sources and switches, e-beam evaporator power sources and switches, process gas lines, mass flow controllers, gas line valves, crystal monitors, ion processes.
   c) Integrated control of system pressure, sample rotation (speed, on/off), sample temperature measured by thermocouple,
   d) Line-by-line ("spreadsheet" or "macro")-based recipe interpreter to store and run processes for multiple layered film growths.
   e) Automatic shut-down of RF, pulsed DC, or DC power supplies if plasma is not detected.
   f) User-programmable shutdown conditions based on system pressure, water flows, gas flows, temperatures, currents, powers.
   g) Interrogation and shutdown conditions using user-defined channels based on input from third party hardware through USB, Ethernet, RS232, GPIB.
   h) Logging of deposition parameters and system parameters during execution of process recipes.
   i) Computer(s) will have minimum two accessible USB ports for transfer of data to and from the computer. The computer(s) will be capable of direct or wireless connection to the customer's Ethernet network. If direct connection is chosen, the customer will be capable of assigning an internet IP address in a manner that will not conflict with operation of the system.

10) Other required items

a) Closed cycle chiller(s) for all system heat loads.
b) Integrated instrument rack that can accommodate power supplies for all required and optional systems.
c) Sand blaster for system cleaning
d) Installation and training
e) Warranty

OPTION: DC power supply (1000V, 120mA) for substrate bias

OPTION: SiC element radiant substrate heater in place of halogen lamp heaters), able to achieve 1000C for standard sample holders in vacuum and in presence of 5 mTorr oxygen with +/- 1 degree C temperature stability, moves together with substrate during on-axis translation. Stage temperature should be measured by thermocouple, and will be calibrated by optical pyrometry of the sample holder platen at the installation site.

OPTION: Thermal effusion sources (K-cell cells)

a) To be positioned in confocal geometry alongside sputtering guns.
b) UHV compatible with conflat flange mount.
c) Capable of being added or removed from the chamber with appropriate blanking flanges.
d) Maximum operating temperature of the cell is at least 1300C
e) Shielded to minimize cross contamination with other K-cell or sputtering sources.
f) Crucible size of minimum 10cc. Cruc ibles can be removed to exchange materials. Three PBN crucibles will be provided.
g) Sources will be compatible with presence of gallium and volatile elements (Sec. 1d) in the deposition chamber.
h) Each source will have its own computer-controlled power source.
i) Each source has a computer controlled pneumatic shutter and is tiltable.

OPTION: 2-inch sputter targets: GeTe (1:1 stoichiometry) and vanadium dioxide (VO_2)

OPTION: A residual gas analyzer (RGA), capable of operation during deposition, 1-100 amu, differentially pumped if necessary.

OPTION: Liquid nitrogen cold trap for trapping volatiles during baking, mountable to spare 10" chamber flange.

OPTION: Additional magnetron sputter gun

OPTION: Additional thermal effusion cell (K-cell)

OPTION: DC power supply for magnetron sputtering

OPTION: Additional power supply for thermal effusion cell

OPTION: Sputter gun with 3" target for normal incidence short working distance sputtering for installation in chamber center position when e-beam system is not installed.

OPTION: Sputter gun with 3" target for normal incidence short working distance sputtering, mounted on retractable arm for installation in chamber center position when e-beam system is installed.

OPTION: Four pocket e-beam evaporator. Active pocket positioned at normal incidence to sample. Crucible capacity at least 8cc. A computer-controlled power supply controls deposition. x-y sweep. A pneumatic shutter. All associated hardware must fit within the existing footprint and instrument racks. System must be capable of full integration into existing system computer control.

OPTION: Ion source for ion assisted deposition

OPTION: Custom fitted baking jacket

To be included in Evaluation Factors:

1) Offerors must submit a minimum of four references including contact information from customers who have received and operated systems similar to that defined in this specification. The provided references must include each of the following categories at least two times:
    a. Received and operated a sputtering deposition chamber with custom adaptation to a 3rd party sample transfer and sample mounting mechanism
    b. Received and operated a sputtering chamber reflection including high energy electron diffraction within
    c. Received and operated a sputtering chamber including ellipsometry.
    d. Received and operated a system combining sputter guns and thermal evaporation sources (K-cells) within a single chamber.
    e. Received and operated a system combining sputter guns and electron beam evaporation sources in a single chamber.

   Preference will be given to those installed in the continental United States or Canada.

2) US-based service and support and associated response time for customer site repairs is to be provided