STATEMENT OF WORK
HIGH UNIFORMITY ION BEAM ETCHING TOOL

PCN: ____________________

Background

NASA Goddard Space Flight Center (GSFC) has a pressing need to produce ion-beam-etched, thin-metal-film detector elements. These thin film structures are incorporated into x-ray focal planes and are planned for the NASA contribution to the x-ray detector for Athena and other missions and opportunities. Etched thin films of this type are produced in vacuum deposition equipment. Parameters achieved by the thin films, in particular the geometry of the etch, the uniformity of the achieved geometry across the substrate, and the absence of contamination or an excessive level of redeposition on the substrate, are determined by the configuration of the system as well as the performance of the components used in the system. Further, the system must be able to etch a substrate without heating the substrate so that different substrates (also called "wafers") have resulting metal films with very similar electronic properties.

The type of thin film etching needed for NASA GSFC x-ray detector prototypes have several critical parameters that must be met by the equipment prior to acceptance by GSFC. These specifications include uniform etch rate across one four-inch substrates of different metals including gold and bismuth. This uniformity is 3% wafer to wafer as well as +/-3% within wafer. It must be possible that the chamber can attain a base pressure below 2e-7 torr to enable thin film etching in an acceptable level of residual gases. During the etching of the thin films, the substrate temperature must be remain below 80 C to prevent burning or melting of materials onto the surface of the substrate and/or physical changes in the thin metal films being etched. If the requirements for temperature control and/or etch rate uniformity can be exceeded, the vendor should indicate the ultimate capability of the system as this will be considered in the technical appraisal.

The films to be etched will have a thickness of up to 10 microns and require an aspect ratio of the etch features that is narrower than the film thickness. For example a film stack 5.5 microns thick, consisting of 1.5 micron of gold under a 4 micron Bi film, will be etched through the full thickness of the films with an etch feature 3 microns wide. To achieve this aspect ratio, the ion beam etch system will need the ability to tilt the wafer from 0 to 90 degrees in both face up and face down directions. That is, if at 0 degrees the face of the wafer is perpendicular to the incident ions from the ion beam source, then the wafer can be rotated to either plus or minus 90 degrees from that orientation. The rotation should be calibrated to +/-1 degree, motor driven, and be operable with the vacuum chamber open or closed. The tiltable stage should also be water cooled and provide for wafer rotation suitable to maintaining the etch uniformity at typical etch rates for films as thin as 100 nm.

NASA GSFC has found that thin metal films of gold, bismuth, and gold-bismuth bilayers have desirable properties for x-ray detectors when no magnetic materials are sputtered onto or otherwise incorporated into the film. Thus, it is critical that no etching of magnetic or ferrous (i.e.,, stainless steel) occurs during the etching of the wafer surface and that no magnetic or ferrous materials can accumulate in the body or grids of the ion beam etching source. Any proposal of work should address how magnetic materials have been protected from the ion beam etch and from the surface of the substrate. Further, NASA is producing arrays of detectors with a spatial extent of several centimeters. Of particular importance is the elimination of all sources of potential magnetic contamination during the ion source operation, through use of non-magnetic materials in the ion source housing and in the path between the ion source and the wafers. To enable cleaning of the system, two sets of removable shields will be provided. These shields will protect the chamber walls and door from etch products. The shields shall be comprised of non-magnetic material (such as Al or Ti). The ion beam will be neutralized via a plasma bridge neutralizer, purged for long filament life and located in such a way that it does not erode in the ion beam near the wafer surface or the ion source.

The system will be assessed for ease of use including loading and unloading the wafer. Substrates to be loaded will be 4" substrates that are greater than 250 microns thick and, as such, may be fragile. The system should be computer controlled including control of the vacuum pumping, process gas control, wafer rotation and tilt, and ion beam etching parameters and etching time. The system should be baselined with the above features but can be quoted with *options* for a load lock, SIMS analysis, and other features that will enhance the usability of the tool as well as the achievement of the specifications of the thin film etches.

Objectives

Through this statement of work NASA GSFC will obtain a high vacuum system that achieves very specific specifications for ion beam etch thin metal films including bismuth, gold, and bismuth-gold multilayers.

The specifications for the vacuum system to be obtained by NASA GSFC include strict limits on etch uniformity, substrate temperature control, absence of magnetic contamination, and automated control. Specifications are as follows:

- The vacuum system shall be capable of etching one four inch silicon wafer at a time with wafer thickness down to 250 microns.
- The vacuum chamber shall achieve a base pressure below 2e-7 torr.
- The vacuum system shall come equipped with an ion source capable of at least 12 cm grid diameter which produces an ion beam from a 1.8 MHz RF argon plasma.
- The vacuum chamber shall achieve an ion beam etch of bismuth and gold films with a rate of at least 50 nanometers per minute and +/-3% uniformity from center to edge on a 100 mm substrate.
- The vacuum system shall be capable of maintaining the substrate temperature during the etching of the thin film to less than 80 C without leaving residue on the wafer surfaces from the thermal contact method.
- The vacuum system shall be equipped with all fixturing to clamp the substrate to a chuck with water cooling, tilt to +/-90 degrees from vertical, and *in situ* variable rotation of 0 to at least 10 rpm

- The vacuum system shall be capable of computer automated control of all processes in the chamber including valve control, gauge readout, substrate tile and rotation, and ion beam control. The computer shall be equipped with user interface software that enables ease of all control and monitoring including a log of processes performed in the vacuum system.
- The vacuum system shall be able to achieve aspect ratios of the ion beam etch approaching 2:1 for a 5.5 micron thick metal film. That is, the target feature size for the etch is below 3 microns for these thin film structures.
- The vacuum system shall come with removable shields to protect the chamber walls, doors and ion source from deposition during etches.

NASA GSFC will obtain an ion beam etch system which is fully cleanroom compatible and compatible with the GSFC cleanroom facility including compatibility with all provided utilities (power, compressed gases, chilled water) and safety requirements of the GSFC facility.

NASA GSFC will obtain installation of the tool on site at NASA GSFC

NASA GSFC will obtain training on the tool once installed at NASA GSFC

NASA GSFC will obtain one year of support on the tool for achieving the specifications for the thin metal film etches as quoted by the vendor including improvements as needed to achieve the specifications.

NASA GSFC will obtain a one year warranty on the system for all parts and labor to maintain the functionality of the tool as delivered to GSFC.

Scope

The vendor shall produce etched thin film samples in a comparable system to the one quoted in response to this statement of work. The samples will be of thin film bismuth and/or gold and will be provided by the technical representative at NASA GSFC.

The vendor shall design the vacuum system to meet the general description provided in the "Background" section as well as specifications described in the "Objectives" and "Task or Requirements" sections of this statement of work.

The vendor shall provide sufficient documentation of the design of the vacuum system to the NASA GSFC technical representative to gain approval of the design.

The vendor shall proceed with the build of the vacuum system after getting approval from the NASA GSFC representative.

The vendor shall complete building of the vacuum system at their facility and hold the system at their facility until the NASA GSFC technical representative accepts the tool for shipment to NASA GSFC.

After construction of the tool, the vendor shall provide for samples of etches of coated wafers produced in the tool at their facility in order for the NASA GSFC technical representative to witness the successful demonstration of the tool and to give the NASA GSFC technical representative a testable sample that can be evaluated prior to tool acceptance.

The vendor shall pack and ship the tool to NASA GSFC.

The vendor shall provide for installation of the tool at NASA GSFC.

The vendor shall provide for training of personnel on the tool at GSFC and provide all manuals and documentation pertaining to the operation and maintenance of the tool and its subcomponents.

The vendor shall provide and support a warranty of all components on the tool. If the tool has difficulty reproducing the specifications once installed at GSFC, the vendor shall provide support on the tool to establish end user processes that achieve the target specifications of the gold and bismuth films and gold-bismuth bilayers.

Tasks or Requirements

General

The vendor shall provide a system with all new construction and all new components. No refurbished equipment will be accepted. No refurbished components or subcomponents will be accepted.

The vendor shall provide an ion beam etching system meeting or exceeding specifications listed above. The vendor shall prove through calculations and performance of past systems that the proposed system will meet all specifications.

The vendor shall provide a leak tight system (to 1e-9 scale on a helium leak checker), welded on all ports, ferrofluidic feedthroughs, and flanges that are conflat with copper gasket wherever possible.

System and Pumps

The vendor shall provide a vacuum system with roughing pumps and cryopumps sufficient to pump the system to below 2e-7 torr.

The vendor shall provide a roughing pump with sufficient pumping speed that can be located away from the system and still pump the system to the required crossover pressure in a reasonable time (less than 15 minutes). In the final configuration at GSFC, the pump could be located up to 40 feet away from the pump and be connected by a 4" diameter line.

The vendor shall provide a gate valve matching diameter of the mouth of the cryopump for maximum pumping speed when the cryopump is pumping on the system.

Chamber Configuration

The vendor shall provide a vacuum chamber with a throw distance (the distance from the ion-beam source to the substrate) of less than 15 inches

The vendor shall provide a vacuum chamber with ion beam source in which the thin film etch rate uniformity is +/-3% across a 100 mm substrate (excluding regions covered by or shadowed by fixturing in order to center the wafer on the chuck)

The vendor shall provide an ion beam source supplied with inductively coupled 1.8 MHz RF power to produce the ion beam etch. The RF power supply shall use a capacitive matching network to maintain low reflected power from the ion beam etch that is frequency tuned with an automatic feedback loop to maintain minimal reflected power.

The vendor shall provide an ion beam source that can achieve rates of ion beam etch of 50 nm per min in materials such as thin film bismuth and gold.

The vendor shall provide an ion source with molybdenum grids with a minimum diameter of 12 centimeters. The grid assembly shall consist of two self aligned grids.

The vendor shall provide a vacuum system with the capability of maintaining substrate temperature below 80 C during operation of the ion beam etch continuously for several hours. The vendor shall provide a closed-loop chilled water supply for the substrate chuck.

The vendor shall provide a chuck and mounting fixtures for the 100 mm substrate. The wafer shall be pulled into good thermal contact with a vacuum and that vacuum pressure shall be monitored with a separate pressure gauge circuit to ensure good, reproducible thermal contact is made for each etch.

The vendor shall provide three small fixtures for centering the wafer on the mounting pad on the chuck (as opposed to a continuous ring feature). Non-magnetic, non-ferrous materials shall be in contact with the wafer surface or nearby the wafer such that they may be eroded by the ion beam.

The vacuum system shall be equipped a chuck capable of tilt to +/-90 degrees from vertical and variable rotation of 0 to at least 10 rpm. Both of these features (tilt and rotation) will be computer controlled and adjustable in vacuum.

The vendor shall provide all stainless steel, welded gas manifold for argon gas and vent gas (dry nitrogen) into the chamber. The manifold will include leak tight shutoff valves and, for the argon, a mass flow controller for setting the argon flow to the ion source. Plumbing interior for these gases will be clean and non-contaminating.

The vendor shall provide two spare mass flow controllers with the system.

The vendor shall provide fixturing for all required water cooling for operation of the tool and its components. This includes any water cooling to the pumps, chamber walls, ion source, and substrate holder. Water cooling plumbing will be protected from erosion from ion source and metal fatigue to prevent formation of plumbing leaks and will not be used as a structural support inside the vacuum chamber.

The vendor shall provide an all-metal (again consisting of or protected with non-ferrous materials) shutter for the electron beam hearth with rapid, reproducible open/close mechanism for reproducible etches. The shutter shall be designed to be taken apart and cleaned as needed. The shutter shall be in a compact "clam shell" arrangement where, when actuated, it splits in two pieces which both recess below the surface of the substrate and out of the ion beam.

The vendor shall provide pressure gauging for the tool including ion gauges for pressure below 1e-4 torr and thermocouple gauges or equivalent for pressures from atmosphere to 10 millitorr. The vendor shall provide computer readout of the pressure gauging for input to software controls.

The vendor shall provide a plasma bridge neutralizer for neutralizing the ion beam during substrate etching. The plasma bridge neutralizer shall be purged with dry gas to increase filament life. The neutralizer shall be situated outside of the line-of-sight of the ion beam and be easy to access for changing of the filament.

Electronics

The vendor shall provide all electronics and power distribution for operation of the ion-beam power supply, pumps, valves, ion source, pressure gauge readout, plasma bridge neutralizer and all other operations of interlocks, computer control, automatic valve control, and other system features provided by the vendor.

The vendor shall provide details on the line of sight of the ion beam to the sample to discuss how the mounting scheme prevents all magnetic contamination from getting milled toward the surface of the wafer during cleaning or any use of the ion source.

Windows / Spare Ports

The vendor shall provide at least one window into the chamber for monitoring the ion beam source and the wafer surface.

The vendor shall provide a shutter for the window to protect it from redeposition of etched materials. The shutter shall be manually operable by the user of the tool at the window.

The vendor shall provide at least 3 spare ports with 2-3/4" conflat for user applications.

Shields for walls and shutter

The vendor shall provide removable shields that protect the walls of the chamber. Since these shields may be in line of sight of the ion beam source, shields should be made of or coated with Aluminum, Titanium, or some other low sputter yield, non-ferrous, non-magnetic ion producing material.

The vendor shall provide changeable components for the shutter that can be cleaned while the system continues to be operated.

Automatic Control / Interlocks

The vendor shall provide automatic valve control for pump, vent, and cryo pump regeneration. The vendor shall also provide for a maintenance mode wherein the valves can be accessed for servicing.

The vendor shall provide a computer interface for operation of the ion beam source gun. It should readout and log pressure gauges, gas flows and ion-beam parameters during a deposition run.

The vendor shall provide a programmable computer interface such that sequences of processes can be run either separately or as a series of processes. For example, pump from room pressure, ion beam etch a substrate with set parameters for a set time, vent system shall be executed via computer control individiually or as a series of three processes in a single user programmed sequence.

The vendor shall interlock the system so that, for example, the ion beam source cannot be operated at high pressure, the roughing valve and gate valve cannot be actuated at the same time, etc.

Spare Parts

The vendor shall provide spare parts for the ion beam source assembly.

The vendor shall provide a spare set of shields for the walls of the chamber.

The vendor shall provide a list of consumables such as gaskets and hardware that fit the system

Safety

The vendor shall provide an emergency power off switch that is clearly labeled and accessible to users, posted warnings of high voltage as needed for the ion-beam electronics, and a system the secures all hazards within the system. The system shall be interlocked so that if the hazards are open and accessible, the hazard cannot be actuated (for example, the ion beam power supply cannot be turned on when the skins of the system are open and the area with the high voltage feedthrough is user accessible).

In the event of actuation of the emergency power off switch or any loss of power to the tool, the vendor shall design the system to secure itself with all components powered down and secured.

Warranty

The vendor shall provide a one year warranty for all parts and labor for the tool and its components and subcomponents

Manuals

The vendor shall provide a full printed set of drawings of the tool, electronic schematics of the tool, and operation of the tool.

The vendor shall provide a parts list and operation and troubleshooting manuals for the components used in the tool

Options

SIMS anaylsis – The vendor can provide an option for a subsystem that samples the etch products during the etch and performs a secondary ion mass spectrometer measurement to determine the content of the etch products.

Load lock – The vendor can provide an option for a load lock chamber to maintain the vacuum integrity of the vacuum chamber while loading the substrate into the system.

Selection Criteria

The vendor shall have five systems delivered and operating in the field with similar designs to the system described in their offer in the last five year period.

The vendor shall provide three references that can be contacted that can describe the system delivered by the vendor to their institution. The references will also be asked to speak to the usage of the equipment and its capabilities as well as the installation and training provided by the vendor at their facility.

The vendor will make available samples from one of their ion beam etch systems that can be delivered to GSFC for testing. GSFC will provide substrates coated with gold and/or bismuth with a suitable photoresist pattern. The technical representative at GSFC will verify that the etch is of suitable quality to proceed with the acceptance of the building of the tool.

The proposal made by the vendor will provide sufficient detail to indicate how the specifications for substrate temperature, thin film etch characteristics, and vacuum pressure will be achieved. These should be detailed calculations of the proposed design and/or evidence of performance from existing systems. The technical representative will evaluate the viability of the system based on the details provided.

The proposal made by the vendor will describe how no magnetic contamination will be evident in the thin metal films after deposition and ion clean of the substrate.

Since it is critical that the demanding technical specifications can be met by the tool as quickly as possible, the price is not considered a major factor in the determination of the best proposal for this statement of work.

Deliverables or Delivery Schedule

From Date of Award (DOA), the vendor shall provide a design for the system that meets the technical specifications. The design will include drawings of the proposed system as well as a parts list of all the components to be included in the system. In addition to the drawings and parts list, the vendor will provide supporting calculations to show that the technical specifications for temperature and film thickness will be met. (~ 1 month from DOA)

1.5 months from DOA: After approval of the design by the technical representative (which will take ~0.5 months), the vendor shall provide a schedule for the build of the tool and acquisition of the parts list.

3.5 months from DOA: At this point (roughly halfway through the build of the tool), vendor shall provide an update against the schedule to show how the work is progressing.

5.5 months from DOA: At this point, vendor shall have completed the build and assembly of the tool. The technical representative will visit the vendor facility to operate the tool to produce initial baseline samples and accept the tool.

6.5 months from DOA: One month after acceptance, the vendor shall have installed the tool at GSFC and trained GSFC personnel on the tool.

Government-Furnished Equipment and Government-Furnished Information

NASA GSFC will provide utilities and cleanroom space for installation of the tool per specifications provided by the vendor for electrical power, compressed gases, chilled water, and any other required facilities.

Security

None

Place of Performance

The design and construction of the tool will take place at the vendor facility. The initial technical acceptance of the tool, including operation of the tool to etch a thin metal layer will be performed at the vendor facility. The tool with be packaged and shipped to NASA GSFC for installation. Training of personnel will also take place at NASA GSFC once the tool is installed.

Period of Performance

The period of performance for this statement of work is 7 months from the date of award.

Signature & Title

4/23/2014
Date