WORK ACCEPTANCE, APPROVAL AND AUTHORIZATION

PART I: WORK ACCEPTANCE

Short Project/Activity Name: Center for Integrated Nanotechnologies User Program/IL Backend Processing Laboratory

Primary Customer Contact Information:

Customer Organization: DOE-Scientific User Facilities/CINT,Sandia-Laboratory Directed Research Development Program

Contact Name/Position/Role: Dr. George Maracas: DOE-SUF/NSRC, Julia Phillips: VP-CTP Sandia National Laboratories

Phone: Email:

Roles and Responsibilities:

Technical Point of Contact/Work Planner: Denise Webb, Department-1132, 845-0509, dbwebb@sandia.gov

Work Description:

Since this was an existing laboratory with ongoing programs, this AAA form represents all the activity level work being performed in Laboratory 518/1511. The Backend Processing Laboratory (class 10,000 cleanroom) houses tools that support integration lab activities. Systems located in this room include a HEPA filtered bead blasting system attached to the house exhaust. The system is for cleaning of shielding of the e-beam evaporator systems, sputter system, atomic layer deposition (ALD) system, and chemical vapor deposition (CVD) systems. The ALD reactor components are typically coated with oxides of aluminum, hafnium, and zirconium, in addition to titanium nitride and platinum. CVD components are typically coated with Au, Al, Cu, Ti, Cr, SiN, Si and SiO2. The room also contains a base and a solvent fume hood, which are used for degreasing and etching of parts for use in the cleanroom. There are wafer dicing saws used for dicing of wafers from the integration lab, e.g. Si wafers, GaAs, SiC, and sapphire as well as lapping and chemical mechanical polishing equipment. A scribe and break tool supports cleaving of substrates when dicing is not an option. Support equipment for the lapping and dicing operations includes a low temperature wax bonder and tape mounted. This laboratory supports User projects within the Center for Integrated Nanotechnologies, and is supported by the DOE-BES-Scientific User Facilities program (Project 146433).

Facilities/Laboratories/Locations:

Building 518, Rooms 1511

Clearance/Badges/Access Required

Not Required/Sandia Site badge

Compare Proposed Work to Approved Operating Envelope/Safety Cases:

Does the scope, hazards, and controls for this work fall within the bounds and limitations of the approved operating envelope and Safety Case authorization basis? ☒ Yes ☐ No

If "Yes" list the Operating Envelope/Safety Cases Document and Version Number:

Operating Envelope/Safety Case # 1132-1511 (Issue # Rev 1, 7/28/2014)

Go to Part II: Work Approval.

If "No" enter what needs to be done to accept this work:

Accept, Reject or Continue Work:

Work is: ☒ Accepted ☐ Rejected

If rejected, state reason:

Line Manager Approval: Jeffrey Nelson, 1131 Date: 7/28/2014

PART II: WORK APPROVAL

Describe briefly what was done to update the Operating Envelope / Safety Case Documents and approach to perform this activity level work.(if activity level work is covered under existing Operating Envelope/Safety Case, just note this here).

The activity level work represented in this AAA form is covered under an existing Operating Envelope/Safety Case.

Technical Work Documents (TWD):

List the Operating Envelope/Safety Case documents that have been updated or previously approved for performing this activity-level-work.

Number	Title	Approved On:
SOP 1100.001	Working with Hazardous and Particularly Hazardous Chemicals in SNL/NM Center 1100	1/7/2013

Line Manager having approval authority for Operating Envelope/Safety Case and associated TWDs.

Signature: Jeffrey Nelson, 1131 Date: 7/28/2014

PART III: WORK AUTHORIZATION

Confirm Readiness

Line manager walk-down:	☒	Final walk down performed on 7/28/2014
Confirm team training qualifications:	☒	Training confirmed on 7/28/2014
Conduct readiness reviews or assessments:	☒	Readiness Review and Assessments on 7/28/2014

Decision to Authorize Work

Work is: ☒ Authorized ☐ Authorized but with limitations ☐ Not Authorized

Describe/Document limiting conditions to be placed on this authorization:

Line manager having approval authority to authorized work:

Signature: Jeffrey Nelson, 1131 Date: 7/28/2014

OE# 1132-1511
Issue # REV 1
Date 7/28/2014

Operating Envelope for SNL/NM Center 1100

Laboratory: Building 518/ RM 1511

Part A: Laboratory Overview and Background Information

PHS Identification

PHS - SNL08A00071-006 – Integration Lab Parts Clean Room; PHS-SNL06A00448-008 CINT (clean room, all labs) - Integration Lab
NEPA - SNA08-0179- CINT Rm. 1511 – Integration Lab Parts Clean Room

Laboratory Owner

John Nogan, 1132, 284-8863

Work Planning Team

	Organization	Position	Phone	Email
John Nogan	1132	CINT Scientist (SMTS)	284-8863	jnogan@sandia.gov
Anthony James	1132	CINT Technologist (PTNG)	284-9157	arjames@sandia.gov
Denise Webb	1132	CINT Technologist (PTNG)	845-0509	dbwebb@sandia.gov
Jeffrey Nelson	1131	CINT Manager	284-1715	jsnelso@sandia.gov

Date of Laboratory Walkthrough: 7/22/2014

Laboratory Designation/ Decision Maker

Standard Industrial Hazard/ Neal Shinn, Acting Manager Department 1132

Brief Description of R&D Work Performed in this Laboratory

The parts clean room (class 10,000 cleanroom) houses tools that support integration lab activities. Systems located in this room include a HEPA filtered bead blasting system attached to the house exhaust. The system is for cleaning of shielding of the e-beam evaporator systems, sputter system, atomic layer deposition (ALD) system, and chemical vapor deposition (CVD) systems. The ALD reactor components are typically coated with oxides of aluminum, hafnium, and zirconium, in addition to titanium nitride and platinum. CVD components are typically coated with Au, Al, Cu, Ti, Cr, SiN, Si and SiO2. The room also contains a base and a solvent fume hood, which are used for degreasing and etching of parts for use in the cleanroom. There are wafer dicing saws used for dicing of wafers from the integration lab, e.g. Si wafers, GaAs, SiC, and sapphire as well as lapping and chemical mechanical polishing equipment. A scribe and break tool supports cleaving of substrates when dicing is not an option. Support equipment for the lapping and dicing operations includes a low temperature wax bonder and tape mounted.

Hazard Identification

Unacceptable Outcomes:
1. No individual will suffer like-altering injuries while conduction an experiment.
2. No individual or the public will be unnecessarily exposed to chemicals.
3. No individual will come in contact with energized electrical circuits greater than 50 volts AC or 100 volts DC
4. Laboratory equipment shall not be damaged
5. Failure that would stop operations at the facility for more than one month.
6. Facility outages of more than 10 weeks.

Common Hazards (Hazards Covered by Common Center-Level Safety Cases)
Chemical Mechanical Environmental

Specific Hazards (Hazards Covered by a Safety Class)
1. Integration Laboratory Backend Processing 518-1511

Laboratory Technical Work Documents
1. SOP1100.001: Standard Operating Procedures for working with hazardous and particularly hazardous chemicals in SNL/NM Center 1100 Laboratories
2. *NOTE*: This laboratory has a number of *guideline* documents that describe the operations and processes of various tools in Room 1511. Although not formal TWD (ie, SOP, OP, …), they are part of the hands-on training provided to USERS of the facility by the laboratory owner (John Nogan) and CINT Integration Laboratory technical staff (Denise Webb).

Part B: Operations Identification, Hazards and Mitigation

Common Laboratory Hazard Category: Chemical Usage

Description of Chemical Usage Hazards:

Bases: Tetramethylammonium hydroxide, ammonium hydroxide, potassium hydroxide.
Oxidizers: Hydrogen Peroxide

Local exhaust ventilation (LEV) is used for exhausting fume hood effluents, in accordance with LEV guidelines and monitored through the LEV inventory control program. Air discharges are small and consistent with typical R&D operations.

Handling of Acid/Base process chemistries that exhibit a particularly above average risk are clearly outlined in "Chemical Processing Guides". These Chemical Processing Guides can be found in the Acid/Base Wet Bench Tool Specific Notebook.

All activities that involve chemicals will follow the laboratory practices outlined in SNL/NM Center SOP1100.00 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories.

Applicable Technical Work Documents: • SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in SNL/NM Center 1100 Laboratories **These documents are required reading for all authorized workers.**	**Required Training:** • ESH100 ES&H Awareness • CHM100 Laboratory Standard Information and Training • CHM103 Site-Specific Laboratory Safety Training • ENV112 Hazardous Waste and Environmental Management **These courses are required training for all authorized workers.**
Possible Chemical Hazards: • Adverse reaction from contact with incompatible materials. • Fire due to exposure to an ignition source. • Bodily Injury due to absorption, injection, ingestion or inhalation of a toxic substance. • Refer to the Material Safety Datasheets for more detailed information on material specific hazards.	**Mitigation of Chemical Hazards:** Solvents are stored in an approved flammable cabinet. Other hazardous liquids are stored in the appropriate manner per SOP1100.001. A minimum of latex gloves and safety glasses are worn while handling hazardous liquids to mitigate incidental contact and are handled in dedicated local exhaust systems. To mitigate incidental contact, all chemicals are handled with basic PPE (latex gloves and safety glasses) and always in a dedicated local exhaust system. Additional PPE (specific chemical resistant gloves, lab coat and safety goggles) is utilized based on the chemical hazard as per the chemical MSDS and SOP1100.001. All hazardous waste is disposed of in accordance with SOP1100.001.

Common Laboratory Hazard Category: Environmental	
Description of Environmental Hazards: Solid as well as liquid hazardous waste is generated during operation processes.	
Applicable Technical Work Documents: • SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in SNL/NM Center 1100 Laboratories **These documents are required reading for all authorized workers.**	**Required Training:** • CHM100 Laboratory Standard Information and Training • CHM103 Site-Specific Laboratory Safety Training • ENV112 Hazardous Waste and Environmental Management. **These courses are required training for all authorized workers.**
Resulting Hazards: • Environmental concerns if organic solvent should enter the wastewater treatment system. • Solid solvent waste placed in landfill could leach and enter the environment. • Dumpster fire, toxic fumes entering the environment.	**Mitigation of Identified Hazards:** Hazardous waste is collected and disposed of in accordance with requirements in Corporate Procedure ESH100.2.ENV.22 Manage Hazardous Waste at SNL/NM. Waste containers are marked properly.

Common Laboratory Hazard Category: Mechanical hazards	
Description of Mechanical Hazards: Portable power tools are used in operations.	
Applicable Technical Work Documents: • N/A **These documents are required reading for all authorized workers.**	**Required Training:** • ESH100 ES&H Awareness **These documents are required reading for all authorized workers.**
Resulting Hazards: • Bodily injury which could include, sprains, cuts and scrapes. • Eye Injury possible if ANSI approved safety glasses are not worn during this activity.	**Mitigation of Identified Hazards:** If necessary, personnel are provided OJT training on a tool.

Integration Laboratory Backend Processing 518-1511
Safety Case

Safety case development meeting was held for the CINT Integration Laboratory Backend Processing area on 7/22/2013.

Who is the Decision maker?
Standard Industrial Hazard/Neal Shinn, Acting Manager Department 1132

How is the system defined?
Parts Clean area is set up to provide users the following:

- Equipment to perform planarization of thin films and bulk wafers/pieces (Lapping and Chemical-Mechanical Planarization)
- Equipment to perform precision dicing of wafers/pieces (Dicing Saw and Wafer Scribe and Break)
- Equipment for mounting samples for either dicing or lapping processes (Wafer/Frame Tape Mounter and Wax/Substrate Bonder)
- Equipment for wet processing cleaning (Wet Benches)
- Equipment for media blasting samples, etch and deposition chamber components.

Systems considered and evaluated during the team assessment:

- Lapping/Polishing
- Wafer Dicing
- Wafer/Frame Tape Mounter
- Wafer Scribe and Break
- Wax/Substrate Bonder
- Chemical-Mechanical Planarization (CMP)
- Wet Benches
- Media Blaster
- Skin exposure of the following hazardous chemicals:
    1. Tetramethylammonium hydroxide(25% concentrationTMAH)
    2. hydrogen peroxide (H2O2),
    3. ammonium hydroxide (NH4OH)
    4. potassium hydroxide (KOH)

What are the unacceptable consequences?

- Severe injury from contact or inhalation of hazardous chemicals and materials, either acute or chronic exposure.
- Severe personnel exposure to hazardous chemicals via: Skin, Eyes, Inhalation or Ingestion.
- Pinch points
- Thermal contact
- Electrical hazards
- Lifting hazards
- Fire hazards
- Inhalation of hazardous media
- Destruction or damage to tools causing impact to CINT operations that result in the delay of production schedule.
- Environmental harm from hazardous effluent being released into the waste water stream.

- Environmental harm related to the uncontrolled wastewater release above outside of permitted parameters for pH, arsenic or other metals from acid waste neutralization (AWN) to city sanitary sewer system

How can the system fail?

- Hot temperature hazards occur when: A member of the workforce (MOW) opens the bonding chamber at high temperatures (180C) and does not use provided fixture to handle product.
- Pinch points hazards occur when: A MOW operates the bonder chamber lid and cooling station mechanisms.
- High Voltage hazard as many of the systems are powered by up to 120 VAC.
- Using unacceptable materials in bond chamber
- Tool configuration is incorrect for the desired process
- Tool is operated outside of designed use.
- Operator error from not following process procedures in operating procedures (OP)
- Lock-Out-Tag-Out(LOTO) procedures are not followed during maintenance activities
- Tool safety interlocks are defeated
- Tool is not adequately purged in preparation for operator entry into a potentially hazardous environment.
- The dicing tool could have mechanical failure due to operator error which can damage the blade spindle.
  This may cause significant down time and impact to various customers production schedules.
- The Lapping tool may have platen problems from mishandling or polishing with insufficient slurry (causing
- chattering of jig on platen) during operation.
- Exposure to TMAH chemical can occur when:
  1. A member of the workforce (MOW) defeats the tool safety interlocks and/ or does not have on the proper PPE when processing wafers with Tetramethylammonium hydroxide (25% concentrationTMAH)
- Exposure to liquid or vapor during chemical pouring could result in serious injury by:
  1. Not verifying bench is operational
  2. Spills during chemical pouring
  3. Unlabeled chemical containers
  4. Incorrect personal protective equipment (PPE) or contaminated PPE
  5. Incorrect wet bench/drain or incompatible chemicals/container/beakers
  6. Insufficient exhaust
  7. Inadequate procedures and training
- Failure of pressurized chemical lines can be caused by:
  1. Holes, cracks, leaky fitting
  2. Overpressure, regulator failure or clogged lines
  3. Material fatigue or incompatible material
  4. Vibration or pump failure
  5. Human error - improper settings or incorrect assembly.
- Failure of uncontrolled wastewater release can be caused by:
  1. Human error
  2. Failure of filter housings on processing equipment

What are the controls and how do you verify the controls are working?

- Wet chemical equipment installed in the CINT IL is designed for proper exhausting of chemical vapors.
- The exhaust levels are determined by the tool owner/manufacturer.
- The exhaust balancing and annual check are performed by Kirk Air, Inc and follow Sandia's LEV protocol.

- Preventive maintenance schedules for each tool include a periodic check of the exhaust and verification
  of proper measurements.
- The Wet Bench tools will alarm if exhaust is inadvertently lost.
- A pressure gauge located on the exhaust connection to each Wet Bench provides a visual check for the presents of exhaust flow.
- Annual exposure assessments have been performed by Sandia Corporate Industrial Hygiene group.
- Authorized use of a wet chemical processing tool in the CINT IL is administratively controlled through Training
- A user must be signed off by the Key Operator prior operating the equipment.
- Documented controlled training task lists developed by the Key Operator guide the trainer and trainee.
- Training on the proper use of PPE and equipment operating procedures is required prior to authorization of use for the equipment.
- Placard signs are located on each tool that designates the equipment status - Up (green) and Down (red).
- Lock-Out-Tag-Out (LOTO) procedures are adhered to when performing equipment maintenance activities.
- Pressurized systems are enclosed and contained within each tool.
- Each tool has sensors installed that can detect chemical leaks within the tool.
- All tools have emergency power off (EMO) and software interlocks that prevent operation if the system fails.
- All tools have a pressure safety data package that has been reviewed and approved by the subject matter expert.
- The arsenic drain is connected to specific tools that generate effluent solutions containing arsenic.
- The arsenic drain routes to a separate abatement system that removes arsenic from the chemical waste stream.
- All effluent chemical waste is continuously monitored for pH, and periodically sampled for fluoride, arsenic, and other NMED regulated constituents.
- Daily "pad" checks are performed by IL Staff ensure that the Acid Waste Neutralization (AWN) system is working properly.
- Abnormal conditions in the AWN are immediately reported to EOC through the facilities management system to the building operator, and to IL Staff who performs daily operational checks, calibrations, etc., and are on-call 24/7 to respond to address issues.
- In summary, the engineering, administrative and PPE controls within the wet chemical processing area work well. Periodic review of these controls and continuous improvement methodologies are also implemented as needed.
- Engineering Controls in the Parts Clean areas include tool safety interlocks that are incorporated into the tool operating software.

Line Decision on Approval of the Safety Case (completed by management)

(Jeffrey Nelson, 1131 for Neal Shinn, Acting Department Manager-1132) I was part of the work planning team and participated on the development of the safety case for this laboratory. I am comfortable with the level of critical thinking involved in the safety and hazard analysis of this laboratory. I also concur with the implementation of new Engineered Safety Controls (administrative and engineered) that have been implemented as a result of this Work Planning &Controls-Engineered Safety activity.

7/28/2014

Continuous Improvement and Feedback

This OE document must be reviewed, revised (if necessary), and re-signed at least annually in conjunction with PHS renewal. This OE must be revised earlier in response to:

- new hazards (e.g. chemicals) being introduced in to the laboratory,
- recognition of hazards not previously considered, or
- identification of significant improvements to hazard control/mitigation defined in this document,

and other situations where improvement to laboratory safety should be documented. It should be noted that these same conditions may require revision of the laboratory PHS and required training matrix.

Reviews, Approval and Authorization

Prepared by Laboratory Owner

John Nogan	John Nogan	7/29/14
Printed Name	Signature	Date

Reviewed by CINT ES&H Coordinator

Seth Nelson		7/29/14
Printed Name	Signature	Date

Center ES&H Coordinator initials here designate that further review by Industrial Hygiene or other Subject Matter Experts is not required.

Reviewed by Center Industrial Hygienist as required

Printed Name	Signature	Date

Additional SME Review required by Center ES&H Coordinator or Department Manager

Reviewer	Title/Activity	Signature	Date

Approved by Department Manager

By approving the OE and Safety Case, the Department Manager attests that it is an appropriate assessment of the ES&H risks associated with the R&D activities that are authorized to take place in the designated lab(s). The approval signature further indicates that the hazard mitigations specified in this OE and Safety Case are also appropriate.

Jeffrey Nelson, 1131, for Neal Shinn, Acting Manager, 1132	Jeffrey Nelson, 1131	7/28/2014
Printed Name	Signature	Date

Authorized Worker Agreement:

Signature by the Authorized Workers in the following Summary Authorization Table certify that the worker has read, understood, and agree to follow the Operating Envelope (OE) identified in this document. Authorized Workers agree that they will not introduce hazards into this laboratory that are not covered by the PHS, OE, and related documents."

If a new employee (e.g. student, post doc, etc.) is brought in to work in the laboratory, their training must be evaluated by the manager prior to any work being assigned or conducted. Their signature asserts that this has been done.

Printed Name	Signature	Date	Lab Owner Confirm. (initials)	Chemical Operations	Environmental	Mechanical Hazards								
