GENERAL INFORMATION	
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PROCESS, EQUIPMENT, AREA	
Process Name: Photoelectrochemical Etching Equipment Used: Retort stand, Power supply, multimeter, crocodile clips, beakers, measuring cylinders, tweezers, clean room wipes Location/Laboratory: Yellow Room, INOR Laboratory	

Reference documents:

- Nitric acid (HNO3)
- Ammonium hydroxide (NH_4OH)
- Hydrochloric Acid (HCl)
- Hydrofluoric Acid (HF)

Condition of Use:
Yellow Room

1. Equipment conditions:
   1.1. Make sure all the equipment required is available and operational.
   1.2 Check that the acid fume hood is available and ready to be used.
   1.3 The fan/exhaust of the fume hood must always be turned on before and during the use of the fume hood, and should remain running for several minutes after the work is completed.
2. Wear appropriate PPE:
   PPE for HF acid handling:
   2.1 Rubber glove & chemical-resistant nitrile rubber glove
   2.2 Face mask
   2.3 Face shield
   2.4 Safety glasses
   2.5 Lab smock
   2.6 Chemical-resistant apron
   2.7 Rubber boot

Other acid handling:

2.8 Lab smock
2.9 Face mask
2.10 Disposable nitrile gloves
2.11 Enclosed shoe
2.12 Face shield
2.13 Safety glasses

3. Hazardous substance management:

- Place all waste and contaminated materials in their appropriate waste containers (for both solid and aqueous substances).
- Clear spills as soon as possible.
- Avoid clutter, and dispose of unwanted materials as soon as possible.
- After use, ensure that the benches are left in a safe, dry, clean and ready state so that the next user may be able to use it immediately.

Competency Requirements:

[/] INOR Lab Safety Training
[/] Refer to the chemical SDS for reference

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STANDARD OPERATING PROCEDURE	
1.	Process Purpose: To etch GaN sample via photoelectrochemical etching method to produce porous GaN.
2.	Emergency Measures: a. Turn off any running water (DI or town). b. Lower the sash of the fume cupboard. c. Leave a label in the vicinity with your name, date, contact, process name and chemical used. d. Evacuate area immediately. e. Inform INOR Lab staff, equipment owner and leave your return contact details. f. Re-enter area only when authorised by staff and re-start equipment only when authorised by an equipment owner.
3.	Safety Information: i. Skin exposure Nitric Acid (HNO_3): Causes deep, painful burns. Characterized by a bright yellow discoloration (Xanthoproteic reaction) as the acid reacts with skin proteins. Ammonium hydroxide (NH_4OH) : Causes liquefactive necrosis, a process that turns tissue into a liquid-like mass, allowing the base to penetrate much deeper than acids. Hydrochloric Acid (HCl): Causes immediate redness, pain, and "acid burns" on the surface. Concentrated solutions cause rapid tissue destruction. Hydrofluoric Acid (HF): The most dangerous. Dilute solutions may not cause pain for hours, but the fluoride ions travel through the skin to dissolve bone and interfere with nerve function.

	ii. Eye exposure Nitric Acid (HNO_3): Severe burns, corneal opacification, and permanent blindness. Ammonium hydroxide (NH_4OH): Penetrates the eye tissue faster than almost any other chemical. Can cause cataracts and glaucoma within minutes. Hydrochloric Acid (HCl): Intense pain, tearing, and deep corneal ulcers. Hydrofluoric Acid (HF): Immediate destruction of eye tissue and systemic fluoride poisoning through the ocular membrane. iii. Ingestion All Acids/Bases: Cause immediate and severe burns to the mouth, throat, and esophagus. Specific Risks: * Nitric/HCl: High risk of stomach perforation. Ammonium hydroxide (NH_4OH) : Causes severe swelling of the throat (laryngeal edema) which can block breathing. HF: Highly fatal; even a small amount causes a massive drop in blood calcium (hypocalcemia), leading to cardiac arrest. iv. Inhalation of vapours Nitric Acid: Releases Nitrogen Dioxide (NO_2), a choking orange gas. Can cause "delayed" pulmonary edema (fluid in lungs) up to 24 hours after exposure. Ammonium hydroxide (NH_4OH): Pungent odor causes immediate irritation. High concentrations cause "burning" of the lungs and throat spasms. Hydrochloric Acid: Forms an acid mist that causes coughing, choking, and inflammation of the upper respiratory tract. Hydrofluoric Acid: Extremely toxic. Inhalation can be fatal by causing a systemic electrolyte collapse. v. First Aid Nitric acid: 1. Immediately flush skin/eyes with water for at least 20 minutes. 2. Remove all contaminated clothing while under the shower. 3. Seek medical help immediately—NO_2 gas inhalation can cause delayed lung fluid (edema). Ammonium hydroxide (NH_4OH):1. Flush eyes/skin with water for at least 20 minutes. 2. Prioritize eyes: Ammonium hydroxide (NH_4OH) penetrates eye tissue extremely fast. 3. If inhaled, move to fresh air; if ingested, do not induce vomiting (drink water/milk). HCL:1. Flush affected area with water for at least 20 minutes. 2. For inhalation of "fumes," move to fresh air immediately. 3. If skin redness or pain persists after flushing, seek medical attention for chemical burns. HF:1. Flush with water for only 5 minutes. 2. Immediately apply Calcium Gluconate Gel (2.5%) and massage into the skin using clean gloves. 3. Reapply gel every 15 minutes and seek emergency medical care (cardiac monitoring is often required).
4.	Required Consumables:

	Nitric acid DI water Ammonium hydroxide (NH_4OH) Hydrochloric acid Hydrofluoric Acid (All chemicals are used from the lab-repackaged bottle and not directly from manufacturer's bottle)
5.	Required Equipment: • Functional fume cupboard (exhaust, DI water, squeegee) • Plastic beaker(s), glass beaker(s), Teflon beakers, Pipettes, measuring cylinder (plastic), sonicator, power supply, retort stand, lamp, multimeter
6.	Preparation: a. Check that the acid fume cupboard is available, on and operational (exhaust (i.e. tissue test), tap water, DI water). b. Wear required PPE as outlined in “Conditions of Use.” c. Make sure all the equipment required (beakers, tweezers, chemicals, etc) is available and operational. d. Make sure to label the beaker properly and clearly. Put the contact name and phone number of the process owner in front of the fume cupboard
7.	Process Description: a. Turn on the fume cupboard switch and light. b. Pull down the fume cupboard sash to cover face/upper torso. Arrange all the required setups in the fume cupboard. c. Carefully pour a 1:20 ratio of Ammonium hydroxide (NH_4OH) : DI solution into a glass beaker. Place the sample into it using a carbon tip tweezer for 5 mins. Make sure the neck of the chemical bottle is pointing into the fume cupboard when pouring the chemical. Then, pour the chemical into a different beaker and rinse the sample with DI water. Later, pour the used chemicals into the base disposal bottle. d. Carefully pour a 1:50 ratio of HF: DI solution into a Teflon beaker. Ensure that all apparatus is Teflon, including tweezers. Place the sample into it for 20 secs. Make sure the neck of the chemical bottle is pointing into the fume cupboard when pouring the chemical. Then, pour the chemical into a different beaker and rinse the sample with DI water. Later, pour the used chemicals into HF acid disposal bottle. e. Carefully pour a 1:3 ratio of HNO_3: HCl solution into a glass beaker. Place the sample into it using a carbon tip tweezer for 5 mins. Make sure the neck of the chemical bottle is pointing into the fume cupboard when pouring the chemical. Then, pour the chemical into a different beaker and rinse the sample with DI water. Later, pour the used chemicals into an acid disposal bottle. f. Carefully pour 0.5 M HNO_3 into a glass beaker. Place the beaker at the end of the retort stand. Clamp the setup of electrodes (GaN and Pt wire) to retort stand. Then, connect the electrodes (GaN and Pt wire) to the power supply and multimeter.

	g. Lowered the clamp to dip the sample and Pt wire in the 0.5 M HNO_3 solution. Ensure the fume cupboard sash is pulled down fully. The etching process starts. h. After etching, pulled up the fume cupboard sash fully and elevate the clamp holding the electrodes. Remove the electrodes and wash it with DI water. Let the sample dry/use blower to dry the sample. Then, place it in petri dish. i. Dispose of the acid into the acid waste disposal bottle with the respective labels. j. Wipe the fume cupboard or wash the used equipment with DI water. j. Characterize/test the sample.
8.	Finishing Procedure: a. Rinse and clean all beakers and containers with DI water. Put the beakers and containers to the designed storage space inside laboratory to avoid cross-contamination. b. Use water squeegee (scraper) to clean the fume cupboard surface. c. Switch off the fume cupboard light and pull down sash.
9.	Process Control: a. Wear required PPE when handling beakers and samples. b. Use tissue test to check the fume cabinet is functional.
10.	Storage: a. All volumes of chemicals are to be stored in their designated chemical cabinets. b. Beakers and PPE: return to respective storage areas

IDENTIFY HAZARDS							
☐	Biological material	☐	High pressure gases/fluids	☐	Noise	☐	Temperature-Heat
/	Chemicals	☐	Implosion	☐	Powered vehicle	☐	Temperature-Cold
☐	Electrical	☐	Magnetic fields (strong)	☐	Radiation	☐	Vibration
☐	Environmental	☐	Manual handling/ Ergonomic	☐	Sharps/sharp edges	/	FireExplosion

☐ Gravity	☐ Moving parts (crush entanglement)	☐ Slips, trips and falls	☐ Other
☑ Hazardous material	☐ Nanomaterial	☐ stored kinetic energy	

CONTROL THE RISKS								
No.	**Hazardous Substance(s)/Task**	**Hazards**	**Harmful Scenarios**	**Existing Controls**	**Risk Rating (With Control)**			**Is This Reasonably Practicable Y/N?**
					Severity	**Likelihood**	**Risk Rating**	
1.	Chemical name: Nitric acid (HNO_3)	Chemicals:HNO_3 Hazardous materials/ Explosive: Yes Risk of explosion with:ethanol, methanol), acetone, and acetic acid Risk of ignition: paper towels, cardboard, and cotton rags	Inhalation: Intense irritation of the nose, throat, and respiratory tract Ingestion:Severe pain and burning of the mouth, throat, and esophagus Skin contact:Causes immediate, severe deep-tissue burns Eye contact:Intense pain, redness, and lacrimation (tearing) Chronic exposure: chronic bronchitis or airway hyper-reactivity	• Use in acid fume hood • PPE: Disposable nitrile gloves, goggles, smock, face mask, face shield, enclosed shoe, safety glasses • Store away from heat sources- MSDS reviewed Fire extinguisher nearby	3	1	3	Y

			Aggravation of pre-existing conditions:asthma, emphysema, or chronic obstructive pulmonary disease (COPD)					
	Incompatible chemicals mixing: Acetone, Ethanol, Methanol, Isopropanol, Acetic Acid	Explosion						
2.	Chemical name: Ammonium hydroxide (NH_4OH)	Chemicals: NH_4OH Hazardous materials/ Explosive: Copper, Silver, Mercury, and Gold (forms shock-sensitive fulminates/azides) Risk of explosion with: Nitric, Sulfuric, Halogens, Chlorine, Bromine, Iodine, and Dimethyl sulfate Risk of ignition: Ammonia gas vapors, Potassium chlorate, and Calcium hypochlorite	Inhalation: Highly irritating to the respiratory tract; may cause coughing, gasping, and pulmonary edema. Ingestion: Causes immediate, corrosive burns to the mouth, throat, and esophagus; may lead to perforation of the stomach.	• Use in acid fume hood • PPE: Disposable nitrile gloves, goggles, smock, face mask, face shield, enclosed shoe, safety glasses • Store away from heat sources- MSDS reviewed • Fire extinguisher nearby	3	1	3	Y

			Skin contact: Causes severe irritation, chemical burns, and tissue necrosis. Eye contact: Severe irritation, immediate pain, and liquefaction necrosis which can result in permanent blindness. Chronic exposure: Chronic irritation of the respiratory tract and potential lung damage. Aggravation of pre-existing conditions: Existing eye, skin, and respiratory disorders (like asthma).					

	Incompatible chemicals mixing: hydrochloric, sulfuric, nitric acid, chlorine, bromine, iodine, fluorine	Excessive heat, explosion						
3.	Chemical name: Hydrochloric Acid (HCl)	Chemicals: HCl Hazardous materials/ Explosive:Sodium Hypochlorite Risk of explosion with:Sodium, Potassium Risk of ignition:Aluminum, Zinc, Iron	Inhalation:Highly irritating to the mucous membranes Ingestion:Causes immediate, severe burns to the mouth, throat, and stomach Skin contact:Causes painful chemical burns and ulceration Eye contact:evere burns, corneal clouding, and permanent blindness Chronic exposure:dental erosion Aggravation of pre-existing conditions:asthma or bronchitis	• Use in acid fume hood • PPE: Disposable nitrile gloves, goggles, smock, face mask, face shield, enclosed shoe, safety glasses • Store away from heat sources- MSDS reviewed • Fire extinguisher nearby	4	1	4	Y

	Incompatible chemicals mixing:NaOH, KOH	Explosion						
4.	Chemical name: Hydrofluoric acid (HF)	Chemicals: HF Hazardous materials/ Explosive: glass/silica Risk of explosion with: Alkali metals or Ammonium fluoride Risk of ignition: aluminum, zinc, and iron	Inhalation:Extremely corrosive to the respiratory tract Ingestion:severe corrosive burns to the digestive tract Skin contact:dissolve the bone and interfere with nerve function Eye contact:Causes severe, deep-penetrating burns. Chronic exposure:Can lead to fluorosis Aggravation of pre-existing conditions:Individuals with pre-existing bone, kidney, or heart conditions (especially those related to calcium/electrolyte balance) are at extreme risk.	• Use in an acid fume hood • PPE: Disposable nitrile gloves, chemical-resistant rubber glove, goggles, smock, face mask, face shield, chemical-resistant apron, rubber boot • Store away from heat sources- MSDS reviewed • Fire extinguisher nearby	5	1	5	Y
	Incompatible chemicals mixing:NaOH, KOH	Explosion						
5.	Byproduct chemical name (aqua regia): Nitrosyl Chloride	Chemicals: NOCl Hazardous	Inhalation: Extremely toxic; causes severe irritation of the nose	• Use in acid fume hood • PPE: Disposable nitrile gloves,	5	1	5	Y

	(NOCl)	materials/Explosive: Plastic/Rubber Risk of explosion with: Amines, Ammonia, and certain Alkenes (violent decomposition) Risk of ignition: Flammable organic solvents, Carbon disulfide, and finely divided metals	and throat, potentially leading to delayed pulmonary edema and death. Ingestion: Unlikely as it is a gas, but would cause severe corrosive burns to the digestive tract. Skin contact: Contact with the gas or pressurized liquid causes severe frostbite-like burns and corrosive tissue damage. Eye contact: Highly corrosive; causes severe burns, stinging, and potential permanent vision loss. Chronic exposure: May cause chronic bronchitis and permanent decrease in pulmonary function. Aggravation of pre-existing conditions: Cardiovascular disease and chronic respiratory diseases (emphysema or bronchitis).	goggles, smock, face mask, face shield, enclosed shoe, safety glasses • Store away from heat sources- MSDS reviewed • Fire extinguisher nearby				

	Incompatible chemicals mixing: sodium hydroxide, hydrochloric, sulfuric, nitric acid, hydrogen chloride	Vigorous reaction, explosion						
	Chemicals Spill and transport from storage cabinet	Chemicals						
	Autoclave/ oven	Heat						
	High pressure gas	Heat, chemicals						

APPROVAL			
Student's Name: Yuganesini Naidu a/p Siva Kumar		**Supervisor's Name: Associate Professor Dr. Mundzir Abdullah**	
Signature: yuga	Date: 08/04/2026	Signature: ASSOC. PROF. DR. MUNDZIR ABDULLAH Associate Professor Institute of Nano Optoelectronics Research and Technology (INOR) Universiti Sains Malaysia 11800 USM, Penang, Malaysia	Date: 9/4/2026
INOR Lab Safety Officer: NUR NAJWA ALYANI BINTI MOHD NABIL		**INOR Lab Coordinator**: MOHD ANAS BIN AHMAD	
Signature: NUR NAJWA ALYANI MOHD NABIL Pegawai Sains Institut Penyelidikan dan Teknologi Nano Optoelektronik (INOR) Universiti Sains Malaysia 11800, USM, Pulau Pinang	Date:	Signature: MOHD ANAS AHMAD Pegawai Penyelidik Institut Penyelidikan dan Teknologi Nano Optoelektronik (INOR) Universiti Sains Malaysia 11800 Pulau Pinang, Malaysia	Date: 5/5/2026

APPENDIX: RISK RATING METHODOLOGY AND MATRIX

Risk Assessment Methodology

The risk level is determined by evaluating:

- Likelihood (L): Probability of the hazard occurring.
- Severity (S): Impact if the hazard occurs.
- Risk Rating(RR) = Likelihood × Severity

Risk Rating Matrix

Severity ↓ Likelihood →	1 - Rare	2 - Unlikely	3 - Possible	4 - Likely	5 - Almost Certain
5 - Catastrophic	Medium	High	Very High	Very High	Very High
4 - Major	Medium	High	High	Very High	Very High
3 - Moderate	Low	Medium	High	High	Very High
2 - Minor	Low	Low	Medium	Medium	High
1 - Negligible	Low	Low	Low	Low	Medium

Severity Rating (S)

Rating	Description
1	Negligible (no injury, no damage)
2	Minor (first aid case, minor damage)
3	Moderate (medical treatment needed)
4	Major (severe injury, lab shutdown)
5	Catastrophic (death, permanent loss)

Risk Level and Action Plan

Risk Level	Description	Action Required
Low	Acceptable risk	Routine controls sufficient.
Medium	Requires review	Improve controls where practical.
High	Significant risk	Must implement risk controls and increase supervision.
Very High	Unacceptable risk	Stop work immediately; implement strict controls before resuming.

Likelihood Rating (L)

Rating	Description
1	Rare (once in >5 years)
2	Unlikely (once every 2–5 years)
3	Possible (annually)
4	Likely (monthly or every few months)
5	Almost Certain (weekly or more frequent)