



# Materials Growth Facility (MGF)

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This document contains the procedures of the Materials Growth Facility (MGF) and is intended to govern its use and minimize conflicts. This is a living document and can be changed as described in [Section 11](#). Any confusion about these procedures or their intention should be raised with the Director and/or Co-Director. All work in the facility is performed on a best effort basis; project success cannot be guaranteed.

If you have any question about the information contained in this document, please contact the MGF ([mgf-support@udel.edu](mailto:mgf-support@udel.edu)).

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## 1 Leadership and Staff

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The MGF is led by the Director (Joshua Zide) and Co-Director (Stephanie Law). Both the Director and Co-Director are empowered to speak for the MGF, but will discuss with each other before making decisions of consequence. The parent organization for the MGF is the Delaware Institute for Materials Research (DIMR). The Director and Co-Director should keep the DIMR Director informed of any significant initiatives. In the event of unresolvable disagreements between the Director and Co-Director, the Director of the DIMR shall adjudicate.

The MGF has a full-time Epitaxy Engineer (Christopher Schuck), who is empowered to make operational decisions in accordance with these procedures. He oversees the facility, coordinates sign-up schedules, assist users, and perform all day-to-day functions. In coordination with the Epitaxy Engineer, the DIMR staff is responsible for administrative activities such as purchasing, billing, financial reporting, and marketing.

## 2 Scope of the Facility

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The scope of the facility consists of the III-V MBE (Apollo) and the chalcogenide MBE (Artemis).

## 3 Cost of Usage

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MGF usage costs are based on the need to meet the operational expenses for the facility while remaining a federally-compliant service center. These costs will be reevaluated periodically (at least every two years, with more frequent evaluations in the first two years) in consultation with the DIMR Director. Before making any change to costs, all users will be notified in advance. User fees are set on a per-day basis (as defined below) and are inclusive of source material and liquid nitrogen where applicable but exclusive of wafers. Staff-assisted days are indivisible units. Independent users can split a day amongst themselves, but full days must be reserved in all cases.

User Type	Daily Cost (\$/day)	
	Artemis (chalcogenide)	Apollo (III-V)
Independent (expert) internal user	165	176
Internal user (staff-assisted)	275	286
External academic user (staff-assisted)	480	510
External non-academic user (staff-assisted)	960	1020

Although charges are done per day<sup>1</sup>, the user (Person A) is required to leave enough time between the end of their day and the beginning of the next user's day (Person B) to load in new substrates, to outgas these substrates, and to change any cell temperatures that require long stabilization times (e.g. selenium, arsenic, etc.). Generally, Person A will be responsible for loading substrates for Person B, though alternate arrangements can be made if both parties are amenable.

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<sup>1</sup> In the Facility Online Manager (FOM), a day will be defined as 12 hours to allow a day to be easily divided between independent users or different projects, but longer may be used.

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If the actions of Person A cause Person B to be unable to use the instrument (e.g. loading in the wrong substrates, forgetting to change a cell temperature, etc.), Person A will forfeit their next growth day to Person B.

When staff-assisted time that does not involve growth on an MBE (e.g. sample characterization on other equipment) is required, user fees are set on an hourly basis (as defined below).

User Type	Daily Cost (\$/hour)
Internal user (staff-assisted)	50
External academic user (staff-assisted)	100
External non-academic user (staff-assisted)	200

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## 4 Wafers Stocked by the Facility

The facility stocks the most frequently used wafers, which are available to users at cost. Our intention is to maintain an adequate stock of each wafer type, though supplies are inherently limited. Currently, we offer the following wafers:

- 2" GaAs, (001)-oriented (semi-insulating and n-type)
- 2" GaAs, (001)-oriented (semi-insulating)
- 2" GaSb, (001)-oriented (semi-insulating)
- 2" InP, (001)-oriented (semi-insulating and n-type)
- 1cm x 1cm c-plane sapphire

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### 4.1 Using Non-supplied (or Non-pristine) Wafers

Users may provide their own wafers subject to approval by the Epitaxy Engineer and/or the Director or Co-Director. We expect users to use "epi-ready" wafers, but other wafers (e.g. patterned) may be approved, provided their preparation leaves them in a condition unlikely to damage the systems.

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## 5 Standard Calibrations

The following calibrations are standard (calibrations outside these may be the responsibility of the group needing the calibrations). The cost of performing these calibrations (equipment time and wafers used) will be charged directly to the MGF. Using calibrations outside these standard calibrations may be the responsibility of the group needing them or warrant consideration as a collaborator. Calibrations frequently used by multiple groups may warrant inclusion as standard calibrations in the future.

### III-V MBE

- GaAs, AlAs, and InAs growth rates
- GaSb and AlSb growth rates
- InGaAs lattice-matching (to InP) and growth rate
- InAlAs lattice-matching (to InP) and growth rate
- Silicon and beryllium doping in GaAs (generally convertible to other materials)
- Tellurium doping in GaSb

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## Chalcogenide MBE

- Bi<sub>2</sub>Se<sub>3</sub> growth rate
- Bi<sub>2</sub>Te<sub>3</sub> growth rate
- In<sub>2</sub>Se<sub>3</sub> growth rate

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## 6 Equipment Reservation

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### 6.1 Sign-up

Each user (not the Epitaxy Engineer) is limited to three reservations at any given time, and sign-ups may be up to three weeks in advance. The Epitaxy Engineer may make reservations for staff-assisted users. All users should be considerate of others in their sign-ups. When users are unable to use the equipment for an extended period due to partial failures, those users might be given priority to sign-up after the equipment is returned to service (see [Section 6.3](#)). Any exceptions to this require the approval of the Director and Co-Director.

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### 6.2 Cancellation

Users are required to cancel reservations at least 24 hours in advance. If a reservation is canceled with less than 24 hours notice and another person is able to use that time, no penalty will be assessed. If no one is able to use that time, the original person will be charged for the day. Up to one late cancellation per academic year will be allowed without penalty, but all “no-show” reservations will be charged. Mitigating circumstances can be brought to the attention of the Director or Co-Director.

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### 6.3 Partial Failures of a System

Occasionally components of the system fail in such a way that some users are able to complete growths while others are not. Under these circumstances, we may continue to run the system for a limited time (generally not to exceed two weeks, but extensible with approval of the Director and Co-Director) before venting to repair the broken component(s). This decision will be made with the approval of the Director and Co-Director. If this down time has a significant impact on some users, those users may receive some priority in sign-up to mitigate the effect of the delay. When such exceptions to the standard sign-up procedure are necessary, they will be defined in writing, with input from the Director and Co-Director to avoid misunderstandings.

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## 7 Expectations for Independent Users

Independent users must be trained on the system to the satisfaction of the Director, Co-Director, and Epitaxy Engineer. The Epitaxy Engineer will certify when someone being trained to use the equipment may be considered an independent user. While independent users are encouraged to talk to the Epitaxy Engineer about any unexpected circumstances, they will work independently with minimal guidance.

Independent direct users are expected to take a leadership role in maintenance of the system. They will be expected to perform calibrations (at the direction of the Epitaxy Engineer, and without cost to the user), assist with maintenance of the system, or perform other laboratory tasks as

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needed. While the intention is that this should not be a large time burden, during servicing this may require a significant time commitment.

If an independent user has a medical condition (e.g. chemical sensitivity, pregnancy, illness, etc.) that makes performing certain laboratory tasks a safety concern, they may be precluded from those tasks and expected to make up for the time burden placed on the other independent users on other tasks or at a later date.

## **8 Safety Procedures**

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Users are expected to comply with all safety procedures set forth by the University of Delaware and all standard operating procedures established for the use of equipment.

Independent users are expected to receive and maintain all standard University of Delaware laboratory safety training, as well as respirator training.

Independent users may work during off-hours (Monday-Friday between 6 pm and 6 am), during weekends (Saturday and Sunday), or on official holidays if necessitated by facility or individual schedules. For safety and accountability, the following rules must be complied with during these off-hours:

- 1) Receive approval from the individual's primary investigator and the MGF epitaxy engineer ahead of time.
- 2) Notify the MGF engineer upon arrival to and departure from the MGF.
- 3) Self-assess their level of awareness and energy. MGF equipment is not allowed to be operated by anyone feeling tired or fatigued.
- 4) Do not perform any maintenance tasks or equipment repairs without permission from the MGF engineer.
- 5) Do not use any flammable, explosive/reactive, corrosive, oxidizing, toxic, or otherwise harmful substances.

Penalties for willful non-compliance will be determined by the Director, Co-Director, and Epitaxy Engineer. Penalties could include temporary or permanent bans from using the MGF. This is not intended to punish mistakes, therefore users who confess to unintentionally violating a rule or breaking equipment will generally not be penalized unless violations are repeated or frequent.

## **9 Intellectual Property of External Users**

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To respect the intellectual property of external users any information about their growths (recipes, logs, etc.) will only be available and accessible by the Epitaxy Engineer, and will only be accessed when expressly needed to perform research functions for those external users. To ensure this, the epitaxy engineer will make such data impossible for other users to access, unless the external user provides written permission with conditions for them to be shared.

## **10 Exceptions to Procedures**

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Minor exceptions to these procedures can be approved by the Epitaxy Engineer, with the expectation that s/he will notify the Director and Co-Director. More significant exceptions to these procedures are possible with the approval of the Director or Co-Director. The Director or Co-Director should not approve an exception unilaterally if the other could be reasonably expected to object. If a procedure requires frequent exceptions, a change of the procedure will be considered as described below.

## **11 Procedures for Changing This Document**

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This is intended to be a living document that changes and evolves as the need arises. Accordingly, an agreement between Director and Co-Director can change this document if they feel such a change is beneficial to the facility. Any change with significant budgetary impacts will require approval of the DIMR Director. Any change with significant impacts on users will be communicated to all users upon adoption.

## **12 Revision History**

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REVISION #	DATE	REVISION #	DATE	REVISION #	DATE	REVISION #	DATE
1	9/11/19	1.2	2/19/21				
1.1	9/16/19						