

University of Arkansas College of Engineering
High Density Electronics Center
Policies and Procedures

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Section 1. High Density Electronic Center Overview

1.1. Program of Excellence

Since its inception, the University of Arkansas' High-Density Electronics Center (HiDEC) has pursued a program of excellence in research and education that has earned the program a national and international reputation. Several U.S. patents have been issued on HiDEC inventions and a number are pending. HiDEC papers are regularly presented at every major conference dealing with electronic packaging or packaging materials.

Several HiDEC research projects have been funded by, and performed for, companies in the electronic, biomedical, and aerospace industry. Projects have ranged from simple MCM designs to an entire technology development and reliability evaluation.

UA graduate students have a unique opportunity to pursue a degree with an emphasis in electronic systems and multichip technology. Extensive hands-on laboratory experience has led graduates to exceptional jobs in industry with leading companies such as Advanced Micro Devices, Anadigics, Harris, IBM, Integrated Device Technology, Intel, Lucent Technologies, Micron Technology, Motorola, National Semiconductor, Northrop Grumman, Raytheon, Sheldahl, and Texas Instruments.

1.2. Brief History

The research center began as an outgrowth of work conducted on thallium-based high temperature superconducting materials and their subsequent application to superconducting multichip modules (MCMs). HiDEC research has expanded to include work on synthetic diamond MCM substrates, low cost MCM design techniques, flip chip die attachment, integrated passive components, and other aspects of high-density electronic packaging. The thin film facility originated from a partnership between the University of Arkansas and nChip that involved renovating a Truck and Tractor repair building into a thin-film processing lab. Operational in 1993, the HiDEC facility includes nearly 4,000 sq. ft. of cleanroom space initially specified at class 1000/100 (ISO class 6/5 respectively) for conventional MCM processing on 125 mm wafers. The HiDEC complex also began with reliability, wideband electrical characterization, and CAD laboratories in the adjacent UA Engineering Research Center and has since expanded these capabilities.

1.3. Mission

The High-Density Electronics Center is a globally competitive core R&D facility that provides the tools, education, and expertise to enable groundbreaking electronics research, prototyping and fabrication to meet academic and industrial needs.

1.4. Core Competencies

HiDEC's expertise can be organized under six general headings: MCM technology, LTCC technology, Integrated Passives, MEMS, Analysis/Reliability, and CAD/CAM. A limited list of skills in these areas is shown below:

Power Module Technology

- Packaging of SiC-based power devices

LTCC Technology

- LTCC fabrication from design to testing
- Cavities
- Full tape thickness features

Analysis/Reliability

- Thermal shock / thermal cycling

CAD/CAM

- Artwork conversion

1.5. Center Capability Overview

The Center consists of thin- and thick-film manufacturing labs, as well as satellite lab facilities that provide additional fabrication and characterization capabilities, including the following:

HiDEC LTCC	HDEC 101	CNC via punching, Screen printing, Vacuum sealing and lamination, Hot knife cutter, firing ovens, dicing saws
Power module	ENRC-4802	Vacuum reflow, Sikama reflow, Die attach, Heavy & conventional wire bonding (aluminum)
Reliability	ENRC-4312	Thermal Shock, Temperature cycling
Analytical	ENRC-4308	3D Printer, scanning acoustic microscope, Cross-section lab & microscope, CNC milling machine, Pull test & Die shear tester, Profilometer
Power Module Lab	ENRC-4607	Chemcut developer, stripper and etcher, dry film laminator & exposure tool

Section 2. Lab Access and Fees

2.1. Access

2.1.1. Card Reader Access

Access to most labs is obtained through a university-distributed ID card. Information on how to have a card encoded to access the various HiDEC facilities is available through the HiDEC orientation session.

External users (employees of companies in the Arkansas Research Technology Park and elsewhere) should apply for an "Affiliate" card at the ID card office in the Arkansas Union. **Users doing this should be certain to tell the person in the ID card office that they need their ID card encoded for card reader access.**

Due to safety and other concerns, card reader access to a given laboratory will only be issued after the lab manager for that laboratory has sent an email to the HiDEC staff member responsible for granting card reader access indicating their approval to grant access.

2.1.2. Keys

Access to most HiDEC lab facilities is controlled via the University ID card reader system. Office keys

are acquired through the HiDEC key administrator after the HiDEC director and/or the Department Head of Electrical Engineering have given their approval. Actual keys to lab facilities is no longer available.

2.1.3. Buddy System

For safety reasons, no user can work in the lab alone after 5:00 pm on weekdays or at any time during the weekends. After use access is limited and requested on a one-off instance. The request needs to include the person that will be with you while in the lab.

Any user found in the cleanroom alone after hours will be banned from using the facility ever again. There are no second chances.

A “buddy” is defined as another individual who has undergone the HiDEC orientation session and thus knows the appropriate procedures to take in the event of an emergency. It is the responsibility of each user to check and see if they are the last person in the area.

If a user’s departure from the lab would result in another lab user being left alone, the person intending to leave should give the last person fair notice of their intent to leave BEFORE they intend to do so, so that the other user has time to shutdown tools or complete their activity.

2.1.4. Tour policy

Due to the sometimes-sensitive nature of the research in Center facilities and to avoid possible interference with equipment installation or facility repairs, all tours must be cleared and supervised by the Director or (in his absence) a HiDEC staff member. If possible, at least 24 hours of notice should be given before the scheduled event. Tours should be arranged with a HiDEC staff member or through the office of the Director.

2.1.5. HiDEC Rates and access eligibility

HiDEC’s fee schedule is based on an individual equipment rate and can be found under section 3.5 Equipment Rates at the end of this document for both academic and industrial users.

Before utilizing any HiDEC facility, all lab users must undergo the HiDEC orientation (Phase II Right-to-know) session. More detailed information on the requirements of this Phase II orientation is given below under Section 3.3. Note that **external companies that have employees in the cleanroom will need to have proof of liability insurance on file with HiDEC before entering the cleanroom.**

2.1.6. Laboratory Rates

Except where noted in section 2.1.7, charges are billed in quarter hour increments and are based on specific equipment utilized. Charges begin from the time the student prepares the tool for use and end when he/she completes the final shut down procedure. Therefore, it is important for everyone to submit their usage on SharePoint accurately. It needs to be pointed out that some tools have an additional material charge and staff assistance will be charged in addition to the equipment charge. Typically, lab fees are collected on a monthly basis, although this schedule can be adjusted if warranted by the needs of a sponsor.

2.1.7. Staff Support

Staff support charges are for process training and support. The HiDEC orientation session (Phase II Right-to-know) is free. Staff is available to answer questions and offer advice without charge within reason; however, projects that require major technical assistance (project consultation exceeding a cumulative two hours and/or hands-on support) will be subject to staff support charges. To facilitate better communication, researchers are encouraged to structure projects as joint research efforts with staff members whenever possible.

2.1.8. Supplies

Supplies are no longer covered under the equipment lab fee, and these include general consumables such as gloves, hair nets, and cleanroom paper. Supplies that fall under the category of “Miscellaneous Charges” include chemicals, raw supplies, wafer tweezers, cleanroom notebooks, dicing blades, CNC bits and other similar items.

2.2. Intellectual Property and Proprietary Research

The University of Arkansas and HiDEC pursue academic and research endeavors in an open environment. From the academic side, this means HiDEC will not exclude any individual based on nationality attending any scheduled lab courses run through one of our laboratories. From the research end, this means that HiDEC is committed to freedom of access by all interested parties to our facilities. While most work conducted at HiDEC falls under public scrutiny, a certain amount of proprietary research is also pursued. **By default, the University of Arkansas and HiDEC regard the nature of the work carried out by any external lab user as confidential and, thus, will not attempt to claim intellectual property developed independently by external clients using the lab.**

Both academic and industrial users can be present in HiDEC labs at any given time. **HiDEC does not generally provide secure storage locations for project supplies or materials, although some limited storage is available.** The Center makes all possible efforts to comply with export control concerns. **However, it is the responsibility of principal investigators to assure that any concerns regarding confidentiality or export controls be addressed for their respective project.**

For more specific details, all users are strongly encouraged to refer to the University of Arkansas’ Policy on intellectual property.

2.4. Reporting & Acknowledgement

HiDEC generates periodic reports that provide comprehensive statistics on its research efforts and activities. In order to prepare this report, we ask that all users provide a general summary of their research progress annually. Reports should not only include the status of the work, but also technical obstacles that could be overcome with alternative resources; such information can be used to dictate and justify future spending on infrastructure and equipment.

We also ask that all users provide acknowledgement of all research efforts utilizing HiDEC in publications with a sentence that reads “This research was made possible through the use of the High-Density Electronics Center (HiDEC) at the University of Arkansas, Fayetteville,” or by using a similar statement. Presentations should acknowledge HiDEC as well, when appropriate.

It is requested that HiDEC staff be informed of the date and particular conference where research is presented that made use of HiDEC resources and that a copy of any publications be provided for inclusion in the HiDEC library.

Section 3. Laboratory Information

3.1 CAD Resources

The HiDEC Design Laboratory is limited to artwork conversion as it pertains particularly to thick film screen and stencil generation for the LTCC facility. Our tool set includes industry standards such as Autodesk’s AutoCAD and DownStream Technologies’ CAM350™. We also possess GDS-to-DXF and GDS-to-Gerber conversion utilities and can generate the necessary data for automated testing.

HiDEC’s source for screen and stencils for the LTCC facility are supplied by either Metal Etch Services or Sefar depending on the resolution required. A specification and typical cost of these items is shown in the table below. Note that a photomask’s minimum feature is usually one or two microns, but HiDEC’s contact lithography capabilities are limited to two microns. Photo plots and glass photomasks are always shipped via FedEx Priority Overnight shipping, unless otherwise specified.

Mask Type	Specification (Min. Feature / plot size)	Cost Range
Outsourced screen	12x12” screen, 325, 0.9, 45, .005 ET	\$125/screen (plus taxes and shipping)

3.2. Storage

3.2.1. Warehouse

HiDEC utilizes a warehouse located off the ENRC premises for long-term storage of functional accessories for the current set of process equipment in the cleanroom. HiDEC staff members attempt to maintain an inventory of equipment accessories (such as vacuum pumps and chillers) readily available to replace units that fail to insure minimal downtime. The warehouse is not intended to store unused process equipment. A tool that cannot be utilized by HiDEC directly or by a sister laboratory on campus will be turned over to the University’s surplus warehouse in a timely manner.

3.3. Certification

3.3.1. Overview

All users must attend the HiDEC orientation session, also known as the “Safety Training” or “Right-to-Know” session, before entering the cleanroom. This is the second part of a two-phase right-to-know program implemented by the University of Arkansas’ Environmental Health and Safety department that details the hazards and safety concerns specific to the laboratories at the Engineering Research Center.

3.3.2. HiDEC Orientation

The HiDEC orientation consists of a 40-minute PowerPoint presentation specific to the HiDEC facilities, a cleanroom gowning demonstration, and a tour describing the equipment and processes available in the cleanroom facility. Even though HiDEC provides safety training as a part of their admission to the HiDEC facilities, supervising professors are ultimately responsible for the safety of their students and post-doctoral fellows since they are instructed by their supervising professors to perform work in HiDEC facilities. As such, HiDEC cannot assume any liability for any students or post-doctoral fellows.

3.3.3. Cleanroom Entry by Visitors

With prior arrangement, visitors may enter the cleanroom for touring purposes without undergoing the certification process, provided they are always accompanied by a HiDEC staff member and/or approved tour guide. Visitors should still be made aware of key safety information, including the location of fire extinguishers, telephones, and exits immediately after entering.

3.4. Equipment Use & Training

Before using a laboratory tool alone, ALL users must first complete the process of **certification**. To complete this process, a user must make an appointment with a HiDEC staff member and demonstrate to that staff member that they can operate the tool properly and safely. The certification process **MUST** be completed by any lab user (whether a student or an external user) before they use a tool on their own. The staff member will then decide if the user can operate the tool without supervision.

Users that use a tool on their own without first completing certification may risk being banned from the cleanroom temporarily or (if warranted by the flagrancy of the violation) permanently.

HiDEC staff members normally conduct equipment training sessions. However, a student that is proficient with a particular tool can demonstrate the tool's operation to new students and can even allow them to operate the tool in their presence. Similarly, external clients that are proficient with a tool may provide training for others, so long as they have been certified to use the tool themselves. But again, users must be certified by staff first before they reserve a tool on their own.

3.4.1. Reserving equipment

Reservation calendars are online at <https://uark.sharepoint.com/sites/hidec/default.aspx>. Students should visit the site to confirm on the main calendar that the tool of interest has not been reserved for the time slot to be used. Then follow the procedures below to make a reservation on a tool:

- a. (HiDEC Cleanroom open) only available for use Mondays, Wednesdays, and Fridays from 8am to 3pm. Other HiDEC facilities are Monday through Friday from 8am to 5pm.
- b. (All HiDEC facilities) 24-hour advanced e-mail notice to be provided to all staff members involved in scheduling: Lauryn Hyles (lhyles@uark.edu), Tom Cannon (tcannon@uark.edu), Gary Jeffery (gjeffery@uark.edu), and (Errol Porter (evporte@uark.edu).
- c. User to provide the day and the start and stop time of each piece of equipment to be used.
- d. User to confirm (on each reservation) the appropriate Worktag or company project code associated with the reservation.
- e. We would request you include both the PI/employer and the associated administrative assistant of the reservation.

A typical email request would go something like what you see below, and staff will send a confirmation email indicating the reservation has been placed in SharePoint or if there is a conflict that would require a different time or day.

"I would like to reserve the following equipment:

Ushio 4150 punch (LTCC): 1:00pm to 2:00pm, Wed., July 13th

WorkTag: (GR09999)"

3.4.2. Accident/Incident/Unsafe condition reporting

Incident reporting is essential to ensure adequate preventative action is taken following an incident and is required by the University.

- 1. Level I Incidents are those associated with violations that put only the offender at risk**
 - a. Example.
 - i. Personal attire violation (shorts & sandals)
 - b. Prior notification structure.
 - i. Proper procedure presented in HiDEC orientation session.
 - c. Penalty.
 - i. First violation results in a written report to user, the associated advisor, HiDEC staff and director.
 - ii. Repeat violation results in access suspension of HiDEC facilities.
- 2. Level II Incidents are those associated with violations that endanger not only the offending party, but possibly other lab users as well.**
 - a. Example.
 - i. Chemical handling violation, equipment/process usage violation
 - b. Prior notification structure.

- i. Proper procedure presented in HiDEC orientation session.
- c. Penalty.
 - i. First violation results in a written report to user, the associated advisor, HiDEC staff, and director.
 - ii. Repeat violation results in access suspension of HiDEC facilities.

3. Level III Incidents are those that endanger anyone through the circumvention of existing safety measures or by intentionally deviating from posted procedures intended to protect the safety of the offender or other lab users. These incident types are considered the most serious because they demonstrate an active attempt to dismiss safety concerns in an attempt to take “shortcuts”.

- a. Example.
 - i. Violating the Buddy System
 - ii. Mixing chemicals without staff supervision and/or permission
 - iii. Intentional circumvention of equipment safety interlocks
 - iv. Using equipment unsupervised without first being “certified” by HiDEC staff
- b. Prior notification structure.
 - i. Presented in the HiDEC policy, orientation, and posted on facility entryways.
- c. Penalty.
 - i. A single violation warrants banishment from all HiDEC facilities.

3.5. Equipment Rate Fees

Equipment description	Service	Academic	Commercial	Room Location
Makerbot	Analytical	\$3.60	\$5.00	HiDEC analytical lab
Stieg CNC milling	Analytical	\$12.00	\$18.00	HiDEC analytical lab
Diamond Elite Band Saw	Analytical	\$9.60	\$14.00	HiDEC analytical lab
Microlux Diamond Band Saw	Analytical	\$7.20	\$11.00	HiDEC analytical lab
Buehler polisher	Analytical	\$12.00	\$18.00	HiDEC cleanroom
Cross-sectioning saw	Analytical	\$3.60	\$5.00	HiDEC analytical lab
Dage 4000 stress tester	Analytical	\$24.00	\$36.00	HiDEC analytical lab
Dektak 3030 profilometer	Analytical	\$12.00	\$18.00	HiDEC analytical lab
Diamond band saw	Analytical	\$3.60	\$5.00	HiDEC analytical lab
Formlabs Form2 printer	Analytical	\$16.80	\$25.00	HiDEC Dark room
Hummer Sputterer	Analytical	\$12.00	\$18.00	HiDEC analytical lab
Logitech Polisher PM5	Analytical	\$12.00	\$18.00	HiDEC analytical lab
Photon Mono stereolithography unit	Analytical	\$9.60	\$14.00	HiDEC Dark room
Zeiss microscope	Analytical	\$3.60	\$5.00	HiDEC analytical lab
Heidenhain VRZ 760B	Analytical	\$3.60	\$5.00	HiDEC assembly lab
ADT 7100 dicing saw	Dicing	\$60.00	\$89.00	HiDEC cleanroom
Disco DAD 320 dicing saw	Dicing	\$60.00	\$89.00	HiDEC cleanroom
Disco DAD 341 dicing saw	Dicing	\$60.00	\$89.00	HiDEC cleanroom
Highmax SHM-200 wafer mounter	Dicing	\$3.00	\$4.00	HiDEC cleanroom
K&S 982-10 Dicing saw	Dicing	\$60.00	\$89.00	HiDEC cleanroom
Formlabs ceramic resin setup	Die Attach	\$42.00	\$63.00	HiDEC Dark room
Sonix scanning acoustic microscope	Die Attach	\$36.00	\$54.00	HiDEC analytical lab
Valhalla 5880A HiPot tester	Die Attach	\$18.00	\$27.00	HiDEC assembly lab
Assembly solder table	Die Attach	\$12.00	\$18.00	HiDEC assembly lab

Deiner Pico-5 asher	Die Attach	\$12.00	\$18.00	HiDEC assembly lab
Finetech die bonder	Die Attach	\$60.00	\$89.00	HiDEC assembly lab
Isotemp vacuum oven	Die Attach	\$3.00	\$4.00	HiDEC assembly lab
Sikama reflow oven	Die Attach	\$12.00	\$18.00	HiDEC assembly lab
SST 5100 vacuum furnace	Die Attach	\$60.00	\$89.00	HiDEC cleanroom
VWR Precondition Oven	Die Attach	\$3.00	\$4.00	HiDEC cleanroom
Audionvac vacuum sealer	LTCC	\$9.00	\$13.00	HiDEC cleanroom
Avure Technologies IL142005 Isostatic laminator	LTCC	\$60.00	\$89.00	HiDEC cleanroom
Blue M BF51732PC-1 Furnace	LTCC	\$3.00	\$4.00	HiDEC LTCC lab
Force draft oven	LTCC	\$3.00	\$4.00	HiDEC cleanroom
Fumehood	LTCC	\$9.00	\$13.00	HiDEC cleanroom
HMI PC-886 screenprinter	LTCC	\$36.00	\$54.00	HiDEC cleanroom
HP 4156C network analyzer	LTCC	\$18.00	\$27.00	HiDEC characterization Lab
LTCC 1500C furnace	LTCC	\$12.00	\$18.00	HiDEC LTCC lab
Micro-tec 550TVC Screen printer	LTCC	\$60.00	\$89.00	HiDEC cleanroom
PTC Hot Knife cutter	LTCC	\$3.00	\$4.00	HiDEC cleanroom
RTC IR furnace	LTCC	\$60.00	\$89.00	HiDEC cleanroom
Stratus AOI inspection tool	LTCC	\$60.00	\$89.00	HiDEC cleanroom
ThermoFisher box furnace (LTCC)	LTCC	\$12.00	\$18.00	HiDEC cleanroom
Ushio 4150 punch (Kapton)	LTCC	\$42.00	\$63.00	HiDEC cleanroom
Ushio 4150 punch (LTCC)	LTCC	\$42.00	\$63.00	HiDEC cleanroom
Ushio 5200ZØ punch	LTCC	\$42.00	\$63.00	HiDEC cleanroom
Ushio 8200Z punch	LTCC	\$42.00	\$63.00	HiDEC cleanroom
LN2 consumption (inch)	Material	\$20.00	\$30.00	
LN2 dewar fill (pound)	Material	\$0.42	\$1.00	HiDEC cleanroom
Stieg CNC copper	Material	\$42.88	\$64.00	HiDEC analytical lab
DuPont 9K7X GreenTape	Material	\$29.00	\$43.00	HiDEC cleanroom
DuPont 951PX GreenTape	Material	\$16.00	\$24.00	HiDEC cleanroom
DuPont LL612 silver ink	Material	\$0.00	\$0.00	HiDEC cleanroom
Upilex (6 x 6 sheet)	Material	\$5.00	\$7.00	HiDEC cleanroom
Lamination bags - inner	Material	\$0.41	\$1.00	HiDEC cleanroom
Lamination bag - outer	Material	\$1.96	\$3.00	HiDEC cleanroom
Autoclave	Reliability	\$1.60	\$2.00	HiDEC analytical lab
Delta thermal cycling	Reliability	\$2.40	\$4.00	HiDEC analytical lab
Tabai thermal shock	Reliability	\$3.20	\$5.00	HiDEC analytical lab
Despatch LEY1-55H Series Humidity Environmental Test Chamber	Reliability	\$6.40	\$10.00	HiDEC analytical lab
Technical Staff	Staff	\$44.00	\$66.00	
Engineering Staff	Staff	\$60.00	\$89.00	
Tormach 1100MX CNC milling tool	Thin Film	\$60.00	\$89.00	HiDEC analytical lab
Amerimade acid wet bench	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Amerimade solvent bench	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Chemcut spay strip	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Chemcut spray develop	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Chemcut spray etch	Thin Film	\$60.00	\$89.00	HiDEC Synthesis lab
Cleanroom Blue M oven	Thin Film	\$6.00	\$9.00	HiDEC cleanroom
Cleanroom inspection microscope	Thin Film	\$12.00	\$18.00	HiDEC cleanroom
Cleanroom spincoater	Thin Film	\$36.00	\$54.00	HiDEC cleanroom
Dry film exposure unit	Thin Film	\$24.00	\$36.00	HiDEC cleanroom

Dry film laminator	Thin Film	\$24.00	\$36.00	HiDEC cleanroom
Exact dispensing vacuum encapsulation	Thin Film	\$60.00	\$89.00	HiDEC Synthesis lab
Karl Suss MJB3 Aligner	Thin Film	\$36.00	\$54.00	HiDEC cleanroom
Solaris 150 RTA	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Specialty Vacuum PV1 E-beam evaporator	Thin Film	\$60.00	\$89.00	HiDEC cleanroom
Hesse BJ 935 heavy wirebonder	Thin Film	\$60.00	\$89.00	HiDEC assembly lab
K&S 4523 aluminum wirebonder	Wirebond	\$20.00	\$30.00	HiDEC assembly lab
K&S 4523 gold wirebonder	Wirebond	\$20.00	\$30.00	HiDEC assembly lab
K&S 4700 hybrid bonder	Wirebond	\$20.00	\$30.00	HiDEC assembly lab
Orthodyne 12mil wirebonder	Wirebond	\$20.00	\$30.00	HiDEC assembly lab
Orthodyne 5mil wirebonder	Wirebond	\$20.00	\$30.00	HiDEC assembly lab