Institutional Infrastructure Improvement for LSU

enhancing

Microfabrication, Materials and Device Technologies for IT

Introduction and Need

The microminiaturization technology is the engine that has driven the high tech industry during the past four decades. Integrated circuits (IC) fabrication process is perhaps the most elaborate and complex manufacturing process ever devised by mankind. It has made possible desktop computing, widespread use of the Internet and advances in mobile wireless communication technology. All these are of fundamental importance to the development and advances in Information Technology (IT).

Facility for LIGA [1] microstructures fabrication is available at CAMD. Deep X-ray along with thick-resist optical lithography is employed at CAMD to fabricate high-aspect ratio microstructures. However, the capability to fabricate electronic circuits is currently not available at LSU or anywhere else in the state of Louisiana. This infrastructure enhancement proposal addresses this serious deficiency.

The proposed fabrication facility complements the currently existing microstructure fabrication capability at CAMD. The microstructures need to be integrated with electronic circuits to provide intelligence and decision-making capability to form smart integrated microsystems. This capability is currently not available at CAMD and is needed for the fabrication of smart sensors and actuators for a variety of applications including physical, chemical, mechanical and biochemical microsystems. Integrated microsystems are increasingly finding newer applications in medicine, defense, environmental sciences, communications, consumer products, entertainment, transportation and civil infrastructure systems. Their applications include automobile airbag systems, trigger code mechanism on large bombs, handheld phones, mobile computing platforms, hand-held environmental monitors and newer drug delivery systems.

Goal

In this proposal, a fabrication facility that merges two key technologies - that of MEMS[1] and microelectronics is requested. This facility focuses on the applications that lie at the intersection of these two technologies in the area of IT. Examples include high Q RF inductors, tunable capacitors and filters for RF wireless handheld phones and portable devices, and switches for optical communication for high-speed data transfer in the broadband applications.

The proposed infrastructure enhancement will also increase the scope of research possible at LSU in the area of application of nanomaterials to MEMS microstructures. Much of the fabrication capability requested here is common to conducting research at the intersection of these two very important technologies.

[1] MEMS is an acronym for Micro-Electro-Mechanical Systems and currently stands for a technology for fabrication of microstructures utilizing techniques largely derived from silicon IC fabrication technology.

The proposed fabrication facility will be housed at the CAMD facility. Some device electrical characterization equipment will be housed in the Electronic Material and Device Laboratory (EMDL) in the Department of Electrical & Computer Engineering.

The benefits of the proposed infrastructure enhancement go beyond the current IT discipline for it also addresses certain aspects of a deficiency cited by the AAAS committee of external reviewers on Materials Program at LSU - specifically a lack of infrastructure in electronic materials [2]. The proposed infrastructure enhancement also addresses five of the six areas listed in the State's Vision 2020 Plan. It directly addresses 'Micromanufacturing', 'Materials' and 'Information Technology' thrust areas of Vision 2020 Plan. It is also in concert with 'Biomedical' and 'Environmental' thrust areas by making possible much needed integrated biological and environmental sensors and detectors for technological advances in those fields.

The proposed fabrication capability at LSU can be looked upon as investment in equipping a kitchen which individual researcher (chef) utilizes to prepare his or her materials, devices, micro or nano-structures or micro or nano-systems (recipe). The goal of this proposal is to provide a basic set of tools (oven, cooking range, utensils). A special recipe may need specialized tool (e.g. a crawfish boiler). This will have to be provided by the chef. An example would be a MBE growth chamber for fabrication of novel structures and high-speed devices for computers and communications. Such a unit may reside at the researcher's lab. However, the researcher will be able to process the material or devices fabricated in the specialized machine at the proposed facility thereby increasing the quality and scope of his or her research.

Infrastructure Enhancement Plan

Specifically this enhancement includes:

- A CMOS fabrication facility housed at CAMD for microsystem integration.
- Some electrical characterization equipment for RF measurements at EMDL.

Fabrication of CMOS circuits is an elaborate and complex process. A CMOS fabrication facility in industry costs well over a billion dollars. By keeping the main fabrication steps in the forefront and by opting for a simple process with less automated equipment, a university fabrication facility cost can be reduced considerably. A compromise in cost and process complexity is inevitable and the budget given here reflects a process that is simple but retains all the critical elements.

The cost in equipment acquisition will be further reduced through active solicitation for used but fully operational equipment from IC industry and purchase of used equipment at a small fraction of its original cost from dealers specialized in used IC processing equipment. The cost given below reflects these cost-saving features. Also, CAMD has some processing equipment already available in-house.

The proposed fabrication process involves seven critical sub-processes. These are 1) wafer cleaning, 2) selective oxidation, 3) optical lithography, 4) doping, 5) silicon deposition, 6) thin film deposition and 7) measurements and diagnostics. In addition, specialized space is needed to house the equipment. At CAMD, about 1000 sq. ft. of clean-room space can be made available to house the proposed equipment. This is a cost saving of over a million dollars since class 100 clean-room space costs over $ 1000/sq. ft. In addition, several hundred sq. ft. of gray-area (class 10,000) will be constructed on the CAMD floor for semi-clean processing. The cost of this additional facility is included here.

Budget Summary:

Year 1 - $1,000,000
Year 2 - $ 600,000
Year 3 - $ 250,000
Total $1,850,000

Year 1:	Equipment to fabricate PMOS circuits at CAMD	$700,000
	VLSI design, simulation and RF measurements at EMDL	$300,000
Year 2:	Equipment for selective doping, CMOS capability at CAMD.	$400,000
	Space modification (gray-room areas), etc. at CAMD	$200,000
Year 3:	Advanced processing equipment at CAMD.	$250,000

Frequently Asked Questions (FAQ)

1. What about the operating costs? – We estimate $ 60,000/year to operate this equipment in terms of expendables and maintenance parts. After the initial period, the external grants and contracts will have to help pay for the equipment operating costs.

2. What about technician help? – We anticipate two full time research technicians for the maintenance and upkeep of the equipment. The details can be worked out between CAMD and colleges utilizing the facility.

3. Why not use foundry services? – It is not possible to conduct innovative research using foundry services for many reasons: 1) Researcher has no control on foundry recipe. Moreover, foundry does not give out their recipe and hence researcher never knows the details of the properties of a fabricated sample. This is crucial information when two technologies are being merged together as proposed here. For example, one can use gate polysilicon in a MOSFET as a mechanical arm for an integrated accelerometer sensor but the foundry will not provide any information on the built-in stress on the polysilicon film. This rules out application of co-fabrication steps that are common to both technologies. 2) In research, several samples need to be fabricated in a sequential manner as seldom does the initial design perform as planned. The foundry cycle time is usually very restrictive and limits research. 3) A student who has both technologies available can carry out innovations in processing which are impossible with a foundry approach. Usually, it is this type of innovations that provide breakthroughs when one is working on the fringes of two separate technologies. 4) Educational component of a hands on learning process possible in an in-house facility can never be over emphasized in research breakthroughs and process innovations.

4. Can we afford this facility? - A facility like this will provide increased visibility and image enhancement instantly for LSU and can be the most visible vehicle for attracting the best and the brightest students from Louisiana and the neighboring states to LSU. It will provide an increase in student and faculty innovation and entrepreneurial start-up activities locally. It will attract bright faculty and improve quality and quantity of interdisciplinary research at LSU and within the entire state of Louisiana. These are important activities for promoting a high-tech business community locally and in the

state. It will of course expand the quality and quantity of externally funded research at LSU and CAMD.

Louisiana has been without a circuit fabrication facility till now. The merging of technologies of microstructures, microelectronics and nanomaterials has provided Louisiana with another window of opportunity to enter the arena and be competitive. We think the time has come to rephrase the question. Can Louisiana afford *not* to have a advanced device and circuits fabrication facility for integrated microsystems?

5. Is there an educational component? – Yes, students from various disciplines from the colleges of engineering and the basic sciences will gain hands-on experience in this technologically important area for the first time in Louisiana. A teaching laboratory will be run utilizing this equipment to train students in their use for cutting-edge research in their respective fields.

Who will benefit?

Since this will be the first such fabrication facility in Louisiana, the proposed infrastructure capability will benefit the entire state of Louisiana. This includes most departments in the colleges of Engineering and Basic Sciences at LSU, Medical schools at Shreveport and New Orleans, AMRI at New Orleans, IfM at Louisiana Tech, and researchers at Tulane, Southern, Grambling and ARC at ULL.

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1. LIGA – a German acronym for Lithographie, Galvanoformung, Abformung.
2. "A Review of the Potential for a Program in Materials Science and Engineering at LSU," Report by the AAAS External Review Team, January, 2001.