# COSMOS nanoFAB

**INNOVATIVE PRODUCTS AND APPLICATIONS REVOLUTIONIZING THE WORLD OF SCIENCE EDUCATION & RESEARCH**

## USER FRIENDLY, MULTI PURPOSE & DESIGNED FOR THE FUTURE

ACST brings to researchers and educators one of its kind, an advanced and multi-purpose desktop micro and nanofabrication instrument that can serve as a research and education tool. While it will allow researchers to take their existing work in different directions, it will enable educators to lay down a strong foundation for students to master industrially useful micron and nano fabrication techniques. **COSMOS nanoFAB** is a fabrication platform; essential to our nano-SCIENTIST™ educational program that prepares students for the abundant opportunities in the growing field of microfabrication and Nanotechnology.

**COSMOS nanoFAB** is designed with a very thoughtful approach to performance, cost, and versatility. Its modular design concept allows the use of common mechanical/electrical components across different techniques resulting in ease of use and lower cost. The instrument is fully capable of being a research tool for rapid prototyping or experimental validation of new research. In the world of education, **COSMOS nanoFAB** will enforce teaching and application of concepts in Surface chemistry, Material science, Industrial applications, Electronic components and fabrication of semiconductors devices, Bio immobilization and bio-sensing applications.

## MODULE 1: INTRODUCTION

Module 1 provides functionality to work on nano and micro fabrication techniquesthat are well recognized in the industry:

- ✓ UV Photolithography:
  Through a series of experiments, students learn the concepts of UV Photolithography: current foundationofthe semiconductor industry.
- ✓ Micro-Contact Printing (µCP):
  Students get acquainted with one of the oldest and lab friendly technique to pattern nano & micro scale features of organic, inorganic and bio materials.
- ✓ NanoImprint Lithography (NIL):
  Students experience and practiceNanoImprint Lithography. NIL is considered by industry experts as the most promising technique that will meet the future demands of the semiconductor industry.

***At its core, COSMOS nanoFAB aims to teach concepts in:***

- *Surface chemistry*
- *Material science*
- *Industrial applications*
- *Electronic components and fabrication of semiconductors devices*
- *Bio immobilization and bio-sensing applications.*

## INSTRUMENT SPECIFICATIONS WITH MODULE 1

| Features | Photolithography | UV NanoImprint Lithography (NIL) | Micro Contact Printing (μCP) |
|---|---|---|---|
| **Nano & Micro Fabrication Techniques Included** | ✓ | ✓ | ✓ |
| **Feature resolution** | 5.0 μm | 100 nm | 200 nm |
| **Max. Exposed Area** | 2.0 x 2.0 cm | 2.0 x 2.0 cm | 6.0 x 6.0 cm |
| **Load Feedback** | Available | Included | Included |
| **UV Exposure** | Included | Included | not required |
| **Educational Labs and Consumables ELC** | Consumables Accessories for 12 Students distributed in groups of 4, 2 labs per application | Consumables Accessories for 12 Students distributed in groups of 4, 2 labs per application | Consumables Accessories for 12 Students distributed in groups of 4, 2 labs per application |

## Hardware Specifications

| | | |
|---|---|---|
| **X axis Resolution w/encoders** | 200 | nm |
| **Y-axis Resolution w/ encoders** | 200 | nm |
| **Z-axis Resolution w/ encoders** | 200 | nm |
| **XY Travel Range** | 60 x 60 | mm |
| **Maximum Sample Size** | 70 x 70 | mm |
| **UV Light Source** | UV LED | Long Life |
| **Maximum UV Output** | 30 | mW (variable) |
| **Load cell Range** | 5,10 | kg |
| **Load Cell Resolution** | 1 | gm |

| Software/Workstation | |
|---|---|
| **User Friendly Interface** | Included |
| **Automated XYZ Stage motions** | Included |
| **Ability to load and save experiment settings** | included |
| **User controlled speeds for XYZ axis** | High precision and controller |
| **Software controlled UV exposure** | included |
| **High resolution load feedback** | included |
| **Programmable stage Interface** | Available (Optional) |
| **Manuals** | Included |
| **Workstation** | All in One<br>Intel® Pentium® processor G2020 (3M Cache, 2.9 GHz)Windows 8, 64-bit Windows 7Wireless Keyboard and MouseWi-Fi ready |

| Equipment Dimensions and Weight | | |
|---|---|---|
| **Height** | 22 in | 55.88 cm |
| **Width** | 13in | 33.02 cm |
| **Length** | 18 in | 45.72 cm |
| **Design** | Desktop | Fully enclosed |
| **Weight (approximate)** | 120 lbs. | 54.43 Kg |

| Facility Requirements | | |
|---|---|---|
| **Electrical Power** | 110/220 – 240 VAC (±50 – 60 Hz), 1 Phase AC Voltage Stability = +/- 1.5%, +/- 1 H , power cable length 6 ft. | Auto switchable |
| **Room Temperature** | 59° - 77° F | 15°- 25°C |
| **Humidity** | 70% or less | |
| **Room space required** | 110 in | 279.3 cm |
| **Bench top (Lab rated )** | 48 x 24 in | 121 x 61 cm |
| **Cleanliness** | Free of dust and other contaminants. | Class 1000 or better if possible |

## UPCOMING UPGRADE MODULES

Two additional modules are already schedule to be release for this instrument.

- ✓ **Module 2**
  Release date: Q2' 15
  Enables Hot Embossing and Thermal Nano Imprint Lithography.

- ✓ **Module 3**
  Release Date: Q4' 15
  Enables2D UV Lithography

# Sales inquiries:


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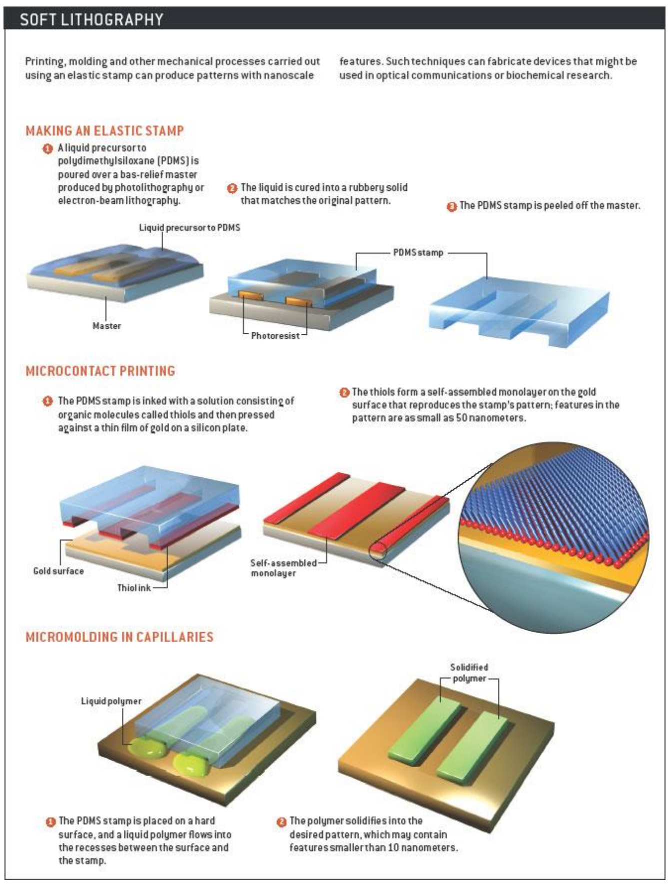
### Advanced Creative Solutions Technology, LLC

Is based in Des Plaines Illinois, distributes and manufactures instrumentation for nano and micro fabrication applications and has a variety of metrology instruments for science innovation.
ACST's mission is to arm educators in their classrooms by providing them a great insight into understanding of the building blocks of materials thru instrumentation, labs, and text books. Greater advancements should come to institutions that can adapt and teach new fabrication concepts along with bringing the theory approach to practice.

## APPLICATION AND MODULE BACKGROUND INFORMATION

**Microcontact Printing (µCP)**

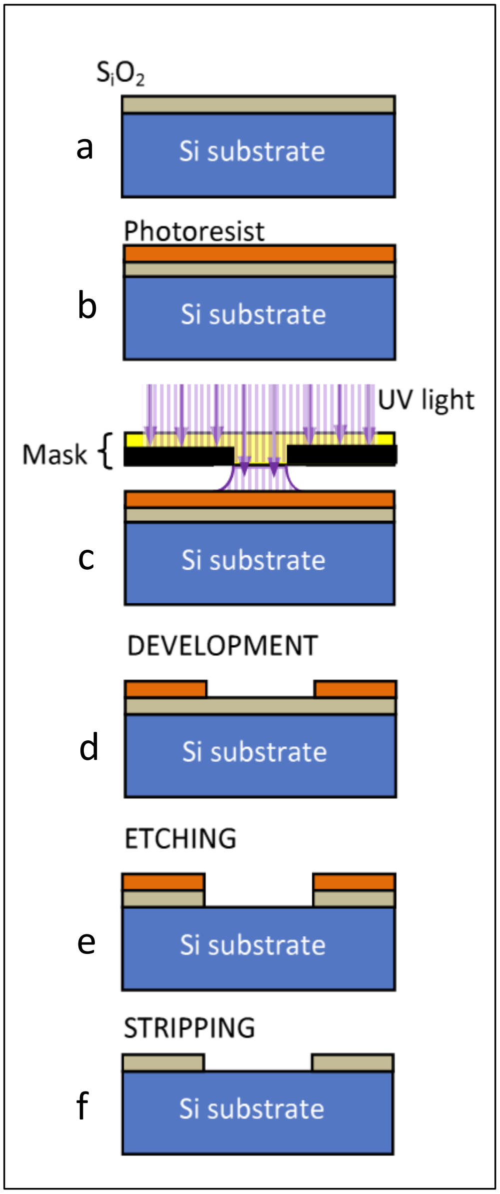
**Description:** Microcontact printing (µCP) is a non-photolithographic technique and a forerunner of "soft lithography". µCP is a very attractive route to pattern micro and nanoscale patterns and structures for applications in biotechnology. It uses an elastomeric stamp to generate two-dimensional micro and nanostructures by printing variety of molecules ranging from organic molecules to large bio-entities onto a solid substrate. This technique consists of two principal steps; fabrication of stamps and printing as shown in figure X1.The elastomeric stamp coated with the desired molecules is brought into contact with the surface and by applying a controlled load; the molecules are transferred to the substrate. Variety of stamps can be generated using different sizes and geometry, for example a very large areas can be patterned easily by using a large planar stamp or a rolling stamp (analogous to a paint roller) to print on planar and non-planar surfaces. The stamp is fabricated from an elastomeric polymer, such as poly(dimethylsiloxane)(PDMS), polyurethanes, polyimide and resins.




**Applications:** Microcontact printing it is a bottom-up fabrication technique, due to its simplicity, high throughput and inexpensive nature it is used in several applications such as optics, MEMS, high density molecular circuits, microfluidics, patterning oligonucleotides for microassays and biosensors, immobilizing cells to study cell-cell and cell-surface interactions, generation peptide arrays for proteins studies and biological ligands for immunoassays and biosensors.

Besides learning basics of the techniques and critical variables, in customized ACST labs, students will explore how computer chips can be printed at the macro and nanoscale or how a biosensor is fabricated. For example, in one of the labs the students will use macro and nano stamps that they will create using a coin for a macroscale stamp, a prefabricated master by photolithography for nanoscale stamp and a polymer. The stamps will be coated with small organic molecules that react with noble metals such as gold and printed on a substrate that has a thin gold film such as a gold DC-R followed by gold wet etching, only the exposed gold areas that are not protected by the organic molecules will be etched, in such an experiment the structures on the stamp will be replicated onto the substrate, an example to demonstrate to students how computer chips are created.

**<u>Photolithography</u>** :




Photolithography is the most successful technology in microfabrication. It is the most useful and profitable industry since its invention in 1959, which was originally developed for microelectronics (integrated circuits planar technology), but now it is also used to make miniature machines (three dimensional structures obtained by exploiting the preferential material-etching along the silicon's crystallographic planes). Since then, the industry has been driven by the demand to build devices that squeeze an ever increasing number of individual circuit elements onto ever smaller pieces of semiconductor materials. Essentially all integrated circuits are made by this technology. Photolithography process is outlined in figure 2, were predesigned patterns are transferred from a photomask (made, for example, using electron beam lithography) to the target silicon substrate (Fig. 2a). The process comprises the following typical steps:

1- Spin-coating a thin layer of ultra-violet (UV) sensitive polymer resist (photoresist) on a silicon wafer sample(Fig. 2b).

2- Subsequently the sample is illuminated with UV light through the patterned apertures of a mask (Fig. 2c); hence only some regions of the resist are exposed to the UV light, which causes changes in the resists solubility. Then the mask is placed as close as possible to the sample without been in contact, illustrated in Fig. 2c. However, due to light diffraction effects, the resist areas exposed to radiation will be larger than the corresponding opening areas of the mask (i.e. there is a loss in resolution). This imposes limitations on lithography-based procedures for creating devices of dimensions smaller than the wavelength. Thus the semiconductor industry has also been driven to use radiation of smaller wavelength.

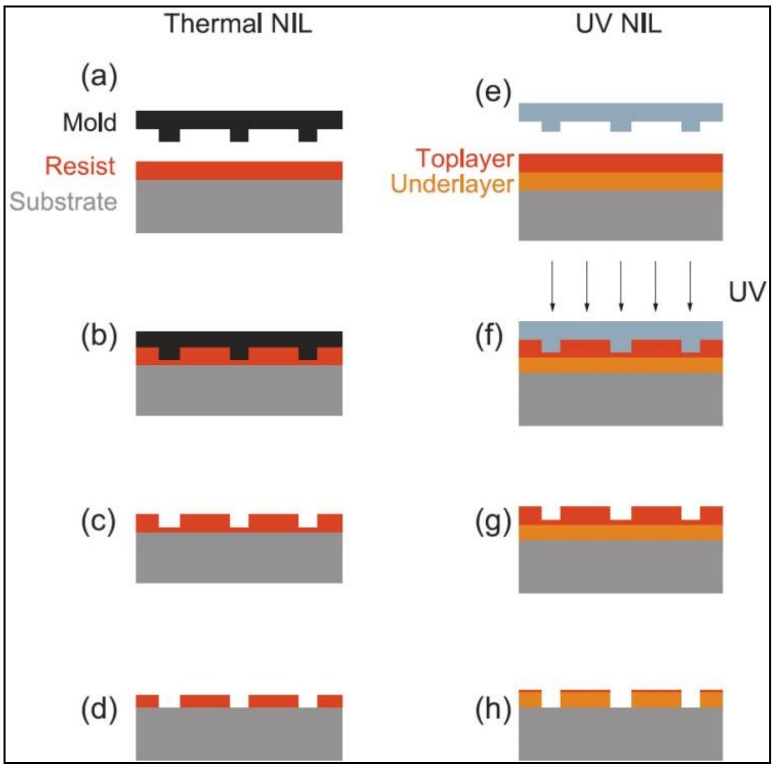
3. After the UV exposure the sample is dipped in a developer in order to remove the resist from the places where it has been exposed to light (Fig. 2d).

4. The resist pattern on the wafer is subsequently used to either etch material from the naked regions where the resist exposes the wafer to the etching agent (Fig. 2e) or, alternatively, to deposit additional material as required by the circuit design. Afterwards, the resist is stripped completely off the wafer (Fig. 2f). After these four steps, features on the mask (step c) will have been transferred to the Si-substrate (step-f). This whole process is repeated as many times as required by the circuit design complexity.

**Applications:** Photolithography is a top-down fabrication procedure, it is the technique of choice in microfabrication because it can produce extremely small patterns down to tens of nanometers in size, and provides exact control over the shape, size of the pattern and is very cost effective. It is used in a variety of industries ranging from microelectronics to life-sciences, and it is and it will continue to be the basis for microprocessors, memories, and other microelectronic devices for information technology in the foreseeable future. In addition it is used in the fabrication and miniaturization of many devices which resulted in performance enhancement, portability, reductions in time, cost, reagents, sample size, and power consumption; improvements in detection limits; and new types of functions.

**<u>NanoImprint lithography (NIL)</u>**

**Description**: Nanoimprint Lithography (NIL) is based on a principle fundamentally different from that for conventional lithographies. This technique demonstrated high throughput, sub-10 nm resolution and low cost, a fact currently impossible for other existing lithography methods. During imprint, the pattern of the mask is duplicated into the resist, either thermally or by UV light. The resist pattern is then transferred to the substrate underneath. In thermal nanoimprint (T-NIL) process (Figure 3a-d), a mold with nanostructures on its surface is pressed into a thin resist cast on a substrate. The resist, a thermal plastic, is deformed readily by the mold when heated above its glass transition temperature Tg due to a low viscosity. After the resist is cooled below its glass transition temperature, the mold is removed and a replica of the mold is left in the resist. In photo-curable nanoimprint (UV-NIL) process (Figure 3e-f), the mold is pressed into the top layer UV resist under room temperature, UV light is then used to crosslink the resist, and the replica of mold left in the resist is transferred to the underlying resist and substrate. In both processes, the mold surface is coated with a passivation layer to prevent resists from sticking to the mold during separation. In the pattern transfer, an anisotropic etching process, such as reactive ion etching ~RIE, is used to remove the residual resist in the compressed area, transferring the thickness contrast pattern created in the imprint into the entire resist.




**Application:** To accelerate nanostructure research and commercialization, one must have a high throughput and low-cost nanopatterning technology, which allows complete freedom in designing the size, shape, and spacing of a pattern. That's why Nanoimprint Lithography is a fast growing field; it has spread into many disciplines, such as microelectronics, biology, chemistry, medicine, and information storage. Promising applications include optical devices, magnetic storage, MEMS, bio-technology, 3D patterning for microwave devices, micro-fluid channels used in bio-technology, ring structures for VRAM, passive optical components etc.