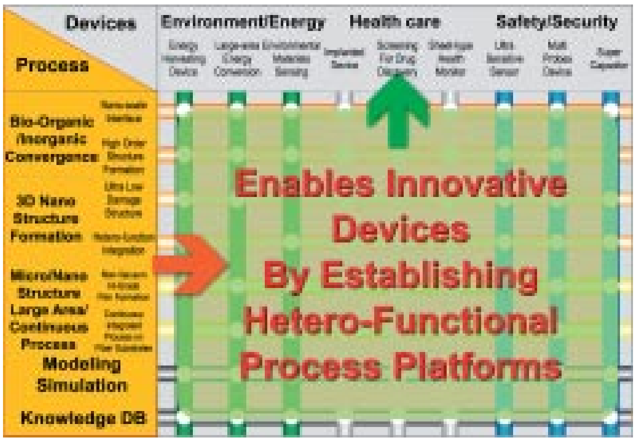
Activities of the BEANS Laboratory

Goals of the BEANS Project

One goal of the BEANS Project is to establish integrated micro/nano manufacturing technologies that combine the top-down approach of micromachining with the bottom-up approach of nano/bio processes, the objective being to produce innovative devices that will revolutionize our lives in such areas as the environment and energy, medical care and welfare, and safety and security. Specifically, we are attempting to merge science and engineering while fusing dissimilar fields such as MEMS and nano/bioengineering. Another goal of the project is to develop a set of new core process technologies (BEANS processes) required to create innovative next-generation devices (BEANS) and to establish these core process technologies as the BEANS platform.

Target of BEANS Project



Below is a description of the goals we hope to achieve upon completion of the project based on the R&D tasks set forth in the basic project plan, and the rippling effect these achievements will have on industry.

1. Bio Integration Processes

- To conduct R&D on processes for forming biomaterials, such as hydrogels and artificial lipid bilayers, having long-term stability. The purpose of this R&D is to establish processes for forming artificial lipid bilayers that are capable of performing biomolecular measurements with great sensitivity and can remain stable for at least one day in biocompatible materials, such as hydrogel and microfluidic devices capable of functioning continuously in the body for at least three months.
- To produce advanced functions by constructing artificial cells and artificial tissues. This will be achieved by establishing process technologies for producing bead capsules using a microbead technique, synthesizing peptides for cell adhesion, and assembling 3D structures of micro-organs and cells for expressing and preserving biofunctions.

2. Organic Material Integration Processes

- To conduct R&D on producing high-performance organic photovoltaic devices. Through this R&D, we hope to establish processes for forming self-assembled nanostructures, such as organic molecular nanopillars spaced at the sub-200-nm carrier diffusion length of the organic semiconductor, organic molecular nanoporous structures with uniform sub-100 nm pores, and mesh or linear structures having a sub-100 nm line-and-space (L/S) pattern. Basic functions such as the conversion rate will be verified based on the envisioned design.

3. 3D Nanostructure Formation Processes

- To produce damage-free 3D nanostructures (nanosize holes with an aspect ratio of 100 or greater) in the etching surface with atomic layer control by developing ultra-low-damage neutral beam etching for use on glass, compound semiconductors, and organic semiconductor material in addition to silicon. Combining this technology with femtosecond laser modification will give us a processing technology for forming complex 3D nanostructures with a precisely controlled isotropic/anisotropic nature to suit the device structure.
- To establish coating and deposition techniques for preventing microstructures from sticking to one another due to interfacial tension, using supercritical carbon dioxide fluid to transport raw material deep into the 3D nanostructure. This technique will also be expanded to embed metal, oxide film, block polymers, and other materials in microtrenches and microholes of 3D nanostructures (nanosize holes with an aspect ratio of 100 or greater) with no gaps. The feasibility of these 3D nanostructure processes will be verified based on envisioned devices.

4. Micro/Nanostructure Large-Area Continuous Manufacturing Processes

- To develop process technologies capable of forming functional films with electronic functions having an electron mobility of 1 $cm^2/V\text{-}sec$ or greater and thin films with mechanical functions constructing micro/nano structures while achieving a practical deposition rate using non-vacuum deposition processes such as coating or self-assembly processes.
- To establish a process technology capable of forming the above high-level functional film over a meter-scale large-area substrate by scanning the substrate to deposit a uniform film thickness within ± 10%, with a patterning resolution no greater than 200 μm and a processing time no greater than that of current vacuum devices.
- To develop processes for forming 3D nanostructures on a fibrous substrate coated with a nanofunctional film at a processing speed of 20 m/min or better, and to develop weaving integration process technologies to create sheet-like devices that function even when deformed three-dimensionally and to verify the functions of flexible sheet-like devices.

In order to apply the achievements acquired above extensively to BEANS manufacturing methods as a platform for processes that fuse different fields, future core processing technologies will be modeled to simulate the processes. We will also create a database with related processing knowledge and expertise to build a design infrastructure for BEANS processes, and will provide licensing for intellectual property rights essential for commercializing BEANS manufacturing techniques in order to remove all obstacles in the patenting process.

In the event that the BEANS Project achieves all of the goals set forth above, BEANS processes will be recognized as a platform for producing innovative devices that can revolutionize the way we live. It is our hope that this platform will contribute extensively to business development and the cultivation of new industries when adopted by companies in diverse industrial fields.