The New Convergence

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Convergence! We keep hearing about product convergence as if it were **the next big thing**. Truth is that *product convergence* has been around for at least a century, but probably for millennia. Many products, like the clock radio, are simple combinations of two mature products. The latest cell phones can receive Internet messages, download and play music, create, store, receive and send photos, and maybe even tune in TV. Although less is said about *technology convergence*, this is also a dynamic and exciting area. In the past, we have combined closely allied technical areas such as audio and video and this old tech duo continues to be the basis for new consumer products. Not much has been revealed about merging dissimilar fields, however. But today, *discoveries are made at the crossroads of diverse scientific fields and products are born at the intersects of technology*.

MicroElectroMechanical Systems (MEMS) and Nanotechnology are certainly two of the top ten technologies for 2006 and biotech is advancing at an accelerating pace to gain recognition, as the secrets of DNA are unraveled through genome projects and related studies. These three important areas are ripe for *technology convergence*! MEMS chips can be made at just the right scale for interaction with biological systems, especially cells, and devices have been built to manipulate and even "operate" on cells. Nanoparticles are small enough to be handled and even pumped by MEMS chips making Bio-Nano-MEMS a natural combination. The merging of Bio, Nano and MEMS appears to be a magic mix of science and technology that can generate synergy to yield unusual results and valuable new devices.

Although many universities are deeply engaged in research involving Biotech, Nanotechnology and MEMS, several of the electronic giants, like IBM, Phillips, ST-Micro, and several of the Japanese powerhouses, have been actively pursuing these three fields. Researchers working on combining these areas into a new *technology triad* have provided interesting bits and pieces of news over the past year or two, but a recent release from Toshiba is worthy of a closer look.

Toshiba has developed nano-manipulation technology that can inject nanoparticles into living cells and ultimately induce specific reactions. These MEMS devices generate subtle vibrations that bond nano-particles onto cellular surfaces and the system can operate on many cells simultaneously. Vibration produced by the MEMS diaphragm causes nanoparticles in a fluid to first attach to cell surfaces. Next, the vibration generates thermal energy that physically alters the cellular surfaces to inject nanoparticles into the cells. The MEMS chip is a nanoparticle manipulator with a water-repellent diaphragm consisting of numerous micro dishes arranged in a lattice format. The cell interaction principle was verified in an experiment utilizing a water droplet containing yeast cells and silica nanoparticles. Toshiba is investigating combinations of various nanomaterials and physical energy levels from the MEMS chip with a goal of developing this technology into a novel non-chemical technique for targeting specific cells. Optimization of the MEMS structure for a specific type of cell may be possible since the mechanical drive can be miniaturized down to a few square microns. Nanoparticles for targets other than cells are also being investigated. Applications could include biological investigative tools for studying the reaction of cells to physical effects and examining their detailed functions. Bio-Nano-MEMS should find medical applications in the future. Perhaps cancer cells will selectively absorb certain nano-particles, "or nano bullets", manipulated by the appropriate MEMS vibrations.

We may safely assume that Bio-Nano-MEMS represents an emerging technological area that will bring important breakthroughs. But as these devices eventually move out of the research laboratory into the realm of commercial development, a new set of challenges will be presented. The first issue will be packaging. We have become so accustomed to the relatively simple requirements for the electronic package, that it's difficult to imagine dealing with more than just piping electrons and shutting out the environment. But the new breed of chips deals with electrons, mechanics, materials, and more. Imagine creating a package that protects a sophisticated electromechanical chip and its electrical interconnects while allowing the entry of biological fluids. Packaging for this field will require more complex and precise enclosures with fluid channels. The good news is that methods, such as microinjection molding, could produce such products, but if even finer features are required, emerging nano-imprinting might be applicable. Will there be more tech mergers in the future? Absolutely! Photonics is high on the list and already part of commercial optical-MEMS products. So stay tuned, as we get closer to fabricating the world on a chip.

Ref. Gilleo, K., **MEMS/MOEMS Packaging**, McGraw-Hill, NY, November 2005.