R&D FACT SHEET
HUMAN++

PACKAGING FOR WEARABLE AND IMPLANTABLE DEVICES

Further miniaturization of implantable and wearable medical technologies, in combination with increased onboard intelligence, will provide more personalized proactive healthcare without sacrificing patient comfort. Advanced packaging solutions and integration technology developed in the microelectronics industry can enable miniaturization of today's medical devices while simultaneously providing added functionality. In the future these new medical devices will promote preventative healthcare solutions at cost effective prices.

APPLICATION FIELDS

- Home monitoring/assisted living for the elderly;
- Personalized health care solutions;
- Wearable health monitoring and diagnostic devices;
- Fitness tracking and personalized training assistance;
- Integrated medical microsystems;
- Implantable microsystems based medical technology (pressure sensors, drug delivery, biosensors, etc.).

POTENTIAL PARTNERS

- Manufacturers of medical devices (implants or external) and of equipment supporting vital sign monitoring for health and sports;
- Medical device OEM;
- Biotech companies (e.g. smart pill, transdermal drug delivery);
- Pharmaceutical companies.

SCOPE

Today's medical implants and emerging wearable diagnostics are advanced and highly specialized systems. Nevertheless, they rely on rather traditional system design and integration technology. The electronic subsystem of these devices is constructed using conventional board-level and/or package-level integration. Although this has enabled a variety of diagnostic and therapeutic applications, the achievable miniaturization remains limited by the chosen integration technology.

The use of advanced 2D and 3D integration technologies such as those being developed for nanoelectronics integrated circuit applications would enable a drastic further miniaturization of the electronic subsystem of these devices. It would also improve yield, testability and cost effectiveness. This research program aims to investigate advanced wafer-level and board-level integration methods such as stacked ultra-thin-chip packaging and flexible/stretchable interconnect technology. These will result in much smaller subsystems that are mechanically flexible and stretchable thus promoting their adoption to wearable health monitoring devices.

Furthermore, application of micro/nano technology to implantable applications requires special measures to ensure biocompatibility while maintaining device function. For in-vivo applications, chips have to be 'sealed' by tight capping layer(s) which serve as a diffusion barrier to prevent body fluids from corroding the chip while simultaneously preventing harmful materials from leaching from the chip. Development of such packaging techniques will provide medical device manufacturers with generic solutions to their application specific problems.

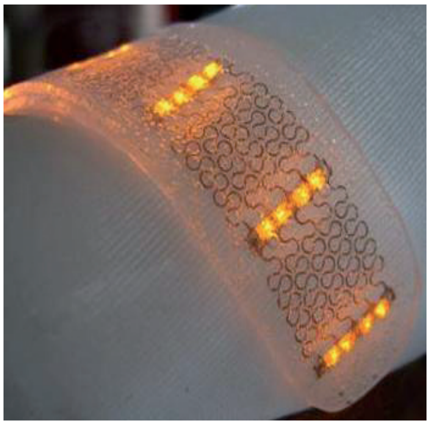
ACTIVITIES

THIN-CHIP EMBEDDING

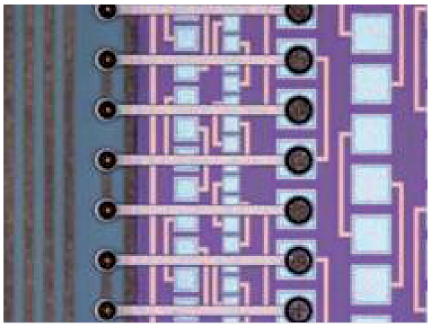
Further miniaturization of microdevices through reduction in both the size and weight will enable a greater number of applications for implantable or wearable medical technology. In support of this activity, imec is developing embedding techniques for electronics, passives, sensors, MEMS, fluidics, using thin substrates. We are refining techniques to thin subcomponents down to 15-50µm without losing any of their functionality or reliability.

FLEXIBLE ULTRA-THIN CHIP PACKAGE (UTCP)

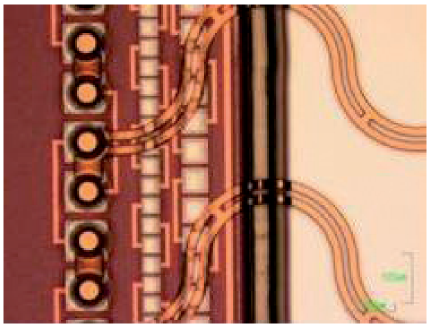
In conjunction with "thin-chip embedding" activities, flexible ultra-thin-chip packages are being developed that focus on board level flexible embedding of thinned electronics in polyimide. At imec not only have test chips been successfully embedded in UTCP, but functional dies (e.g. Texas Instruments MSP microcontrollers) as well. Ongoing investigations are looking into further characterizing mechanics of materials, developing methods to photo-pattern polyimide for definition of holes, stacking of thin UTCP chips, and embedding of optical functions (components and waveguides).



01 Simple LED circuit with stretchable meander shaped interconnects



02



03

02 and 03 Embedded dies with electrical interconnects in BCB (02) and (03) embedded dies with electrical interconnects in silicone (interconnects: 100 µm pitch).

MORE INFORMATION

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▸ FLEXIBLE DIE EMBEDDING WITH HIGH DENSITY INTERCONNECTS

The goal of this activity is to develop a process for the fabrication of thin flexible structures with embedded dies connected with high density metallization pattern. This approach will enable building systems with minimum volume making this packaging technology interesting for portable applications such as health monitoring devices. Wafer level processing is used, enabling the use of advanced IC processing tools, resulting in a high density interconnect pattern.

▸ FLEXIBLE AND STRETCHABLE MOLDED INTERCONNECT TECHNOLOGY

Imec is developing board level integration technologies for elastic electronic and sensor circuits. The goal of these activities is to embed electronics, passives and MEMS into a stretchable platform. Extensive Finite Element Modeling (FEM) calculations have been carried out in order to maximize stretchability and enhance reliability of the overall embedded system including the metal interconnects. Designs with optimized shape, dimensions and pitch interconnects have been fabricated and undergone mechanical benchmarking. Further work investigating the long term reliability of the interconnect technology and integration into textiles is ongoing.

▸ PACKAGING TECHNOLOGY FOR IN VIVO APPLICATIONS

The continued evolution of integrated microsystems containing both MEMS and CMOS circuitry will have an increasingly large impact on biomedical diagnostic and therapeutic medicine. If not packaged properly, the host of metals used in fabrication of CMOS electronics can diffuse through the package causing cell death, as well as the high concentration of salt ions in the extracellular environment can leach through the package causing corroded electronics. To improve device performance and lifetime, and prevent leaching of harmful substances from the implant, imec is developing a post-CMOS compatible wafer level packaging solution.

▸ ELECTRODES FOR IN VIVO APPLICATIONS

Imec is investigating new possibilities to improve the performance of wearable or implantable electrodes. Various novel electrode deposition methods and materials are being investigated and compared. The main metrics being used to benchmark the various electrodes are impedance reduction, increased mechanical robustness and increased charge delivery capacity for stimulation applications.

▸ ELECTRODES FOR WEARABLE ECG AND EEG SYSTEMS

Imec is currently investigating alternatives to the traditional Ag/AgCl wet (gel) electrodes that are currently using in medicine for the recording of ECG and EEG signals. Development of a dry electrode that does not make use of a gel would eliminate some of the problems with wet electrodes such as gel drying, electrode shorting, and patient discomfort. In place of a conductive gel, the dry electrodes would lower the electrode-skin impedance using needles that penetrate the stratum corneum. Additional electrode design modifications are being implemented to counter the effect of motion artifacts and the difficulty of electrode placement on hairy skin.

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