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Microfluidic MEMS: enabling novel biomedical applications

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Abstract
Recent efforts in drug discovery, drug delivery, and diagnostics have driven product development and technology innovation in microfabricated device. Many of these novel microfabricated devices have been enabled by advances in microfluidic device processing and material development. IntelliSense Corporation has designed microfluid devices for biomedical and consumer applications. An investigation of the technology including development and manufacturing is presented.

Introduction
The emerging field of Biomedical MEMS or BioMEMS has been fueled by an increasing breath of applications. Applications such a drug delivery, drug discovery, minimally invasive surgery, and diagnostics are driving an increasing number of MEMS development activities. The development surrounding BioMEMS includes process development, material development, and MEMS product development. Among the increasing array of BioMEMS technologies, microfluidics offers a large variety of application areas.

Microfluidic technology
Microfluidic technologies incorporate the interaction of MEMS devices and surrounding fluids. Common to MEMS sensors are phenomena such as squeeze film damping which have been evaluated and studied for many types of MEMS devices. Squeeze film damping typically refers to the interaction between a moving MEMS component and a surrounding gas. For example, plates or cantilever beams are often positioned just above ground planes. When electrostatically actuated, the plate snaps down and contacts the ground plane. During the movement the gas in the gap between the plates is displaced. The gas displacement significantly influences the dynamics of the system through squeeze film damping.

Other microfluidic phenomena are beginning to be studied as extensively as squeeze film damping as applications for microfluidics for fluid transportation are being developed for biomedical applications. Because small amounts of fluid can be transported through microchannels, opportunities for chemical and biochemical analysis and delivery are being pursued through BioMEMS that actively transport and separate fluids. Among the Microfluidic driving mechanisms are electrokinetics, acoustic pumps, centrifugation, pneumatic and hydraulic pressure, and bubble generation. The appropriate driving mechanism is determined by the specific application requirements.

Microfluidic development

Design of microfluidic devices requires product definition and specifications, material selection, process design, and performance analysis. Critical to microfluidic design, as with all design problems, is the definition of the product requirements. For problems involving fluidic transport and substance detection it is critical to determine the appropriate fluidic volume based on the target concentrations. For low concentration measurements minimum sample volumes may be necessary to provide the appropriate amount of sample for detection.

Material selection is also application dependent and critical to device performance. The selection of materials for mechanical structures and coatings are selected based on both biochemical interactions and hydrophobic or hydrophilic characteristics. Finally, market considerations also influence the selection of materials. The cost of the device can be greatly influenced by the material selection and the associated processing techniques.

Process development and manufacturing

Process selection for MEMS devices is likely the most important design decision in the design process. The selection of a process often defines the performance, reliability, and cost that can be achieved. Well-understood and low risk processes such as bulk and surface micromachining offer the lowest risk path for commercial product development. With existing infrastructure, years of commercial use, and extensive geometric and electronic capabilities, these process often offer the most cost effective and low risk approach. Because MEMS developers and manufacturing facilities are equipped with experience and infrastructure these process offer the shortest development time and most rapid time to market.

Alternative processes are beginning to show promise for some microfluidic applications. Processes such as hot embossing, micromolding, and continuous flow fabrication, promise the advantage of low material cost due to plastic materials and rapid cycle times. As additional research is conducted to characterize these processes, manufacturing capabilities will begin to develop for high volume manufacturing.

Applications and bioMEMS examples

IntelliSense Corporation has a breath of experience in MEMS modeling, device design, process development, and volume manufacturing. With in-house development experts, fabrication facilities and our industry standard IntelliSuite™ software IntelliSense has enabled customers to rapidly and cost effectively commercialize MEMS. IntelliSense will present examples of microfluid devices and biosensors including a chemical and biological sensor based on combined micro-optics (MOEM) and MEMS technology. The sensor combines a sensing waveguide and a microfabricated fluid delivery system. This integration permits analyte samples to be transported to a reaction well in contact with the sensing surface. Design, process, and material selection will be discussed.