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Manufacturing Issues in High Precision Microfabricated Sensors

Andrew Swiecki, Fariborz Maseeh
IntelliSense Corporation
www.intellisense.com

Abstract

Manufacturing issues in high precision microfabricated sensors are among the most critical to successful MEMS commercialization. However, they are often the last to be considered during the product development cycle. As important as the device and process design, manufacturing processes dictate the performance and cost effectiveness of high performance MEMS devices. IntelliSense describes the critical issues in MEMS manufacturing using examples from high-performance sensor product development with examples in accelerometers and bulk micromachined sensors.

Introduction

Traditional product development organizations decompose the product development cycle into several distinct activities. The reasons for the decomposition are straightforward, well understood, and make sense for typical organizations. The actual division varies from company to company. However, a structure that includes R&D, design, test, and manufacturing can be used for discussion purposes. A structure such as this provides a system for management, personnel specialization, resources allocation, and performance measurement. Unfortunately, this serial product development structure has the disadvantage of placing manufacturing issues at the end of the process. The ramifications (such as higher cost and lower performance due to non-optimized designs) of this type of serial process are well understood, and there are many initiatives that attempt to address them. These initiatives demonstrate that there is a need to integrate manufacturing early into the product development cycle for almost any product. However, for MEMS development these issues are even more important.

For organizations interested in commercializing MEMS sensors, manufacturing issues must be addressed at the beginning of the product development cycle. Unfortunately, many follow not only the traditional product development cycle but also follow the traditional MEMS development cycle. The tradition MEMS development cycle originated in universities and research institutions and involves an iterative process of developing a device concept, fabricating it with the processes immediately available, characterizing the device, identifying issues that impact desired performance, adjusting the fabrication process and fabricating it again. After many iterations and much time and money, the developer may have a device that works. By focusing on the problems identified during the prototype process, a device that can be fabricated by prototyping interations is created. This proof of concept is the objective of

university and research programs. This is not the objective of commercial companies and commercial products.

To properly address the manufacturing issues of MEMS the developer of the device must also be the manufacturer. Focusing on manufacturing issues first, the developer will determine the best approach for not only the device but for the development process. Development processes differ depending on manufacturing volume, sales price, and time-to-market requirements.

Manufacturing issues impact the development process

For high volume devices such as automotive acceleration sensors, manufactured in quantities of tens-of-millions of devices, the device developer can consider processes that require application specific capital equipment. In fact, the device design process may include equipment design that enables processes that are not possible with general-purpose equipment. The developer can also plan for long development times that permit customization of equipment. With huge volumes and the associated financial payoff, the cost of a long development can be economically amortized.

Medium volume devices require a different development process. For medium and small volume devices application specific equipment does not make economic sense. Medium volume production should be manufactured with general-purpose equipment so that the capital expenditure is distributed between several products. Development time is also critical for medium volume devices. Long and costly development can not be economically amortized over few devices.

Manufacturing issues impact device design

As described, manufacturing issues influence the first decision in product development, the selection of the design process. Device design decisions, following from the design process, are also directed by manufacturing issues. Yield for example is a large factor in high throughput process. Typically, yield increases of 15% lead to per-die cost reductions of approximately 13%.

For lower volume manufacturing where assembly lines are not running at full capacity, yield becomes less of an issue. If throughput is not at the equipment's capacity, increases in yield do not as significantly decrease the per-part cost.

Acceleration sensor example

Manufacturing issues in microfabrication can be examined using accelerations sensors as an example. There are many markets for acceleration sensors. Examples of markets include automotive, aerospace, and test equipment. The markets differ in the performance, cost, and

volume required. These differences are reflected in the type of MEMS technologies used. They are also greatly impacted by manufacturing issues.

IntelliSense will present examples of manufacturing issues in device development and production. Using actual examples of acceleration sensor development and manufacturing, IntelliSense will highlight the key aspects of MEMS development that are impacted by manufacturing issues. IntelliSense manufactures customer specific MEMS for a variety of applications. In addition to MEMS foundry activities, IntelliSense custom develops MEMS sensors. Combining development and manufacturing, IntelliSense has tackled the difficult issues of microfabricated sensor product development and manufacturing.