Integrated CMOS-MEMS Technology and Its Applications

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Abstract

The paper describes integrated CMOS-MEMS technology and its applications. We discuss the features of integrated complementary metal–oxide–semiconductor-microelectromechanical systems (CMOS-MEMS). The prospect of this integration is also presented. A MEMS fingerprint sensor and a low-voltage radio frequency (RF) CMOS-MEMS switch are the case studies discussed. In conclusion, it is confirmed that the integrated CMOS-MEMS technology will pave the way for the More than Moore technology.

1. Introduction

Fusion of microelectromechanical systems (MEMS) technology with complementary metal–oxide–semiconductor (CMOS) LSI technology is a promising way to develop highly functional devices beyond CMOS scaling. We have been developing the integrated CMOS-MEMS technology that fabricates ultrafine LSIs and MEMS devices on a silicon wafer while providing a seamless bridge to Jisso technologies.

The integrated CMOS-MEMS technology features miniaturization, which leads to a thinner, a more high-functionality, high accuracy, mass-production, not only obtaining high functionality of CMOS circuitry and higher performance of MEMS devices. Specifically, a higher sensitivity of sensing circuits and new principles of sensors for sensing device applications, a small high-performance radio frequency integrated circuit (RFIC) for fabricating multi-band wireless devices, calibration circuitry for MEMS devices as high-quality MEMS technology, and testing techniques for mass-production.

In this paper, first, conventional MEMS technology trends and the position of the integrated CMOS-MEMS technology are described. Next, as the actual case study, MEMS fingerprint sensor LSI [1] with an approximately 60,000-pixel MEMS variable capacitor including sensing circuits to achieve highly sensitive fingerprint detection and an RF CMOS-MEMS switch [2] that enables 3.3 V operation to achieve direct control of CMOS LSIs are presented. Finally, the prospects expected by fusion of CMOS circuitry with MEMS device are discussed.

2. Integrated CMOS-MEMS technology

From the view point of CMOS LSIs, prospects and challenges of the integrated CMOS-MEMS technology is described. Figure 1 shows the correlation between the number of MEMS devices and transistors and indicates the market trends. MEMS parts, such as inductors, are at the lower left. Accelerometers for game devices and/or automotive vehicles and MEMS for inkjet printer heads are located in the center. Even though the MEMS parts market is small-scale, the market for accelerometers is growing due to acceleration sensor-equipped game devices. Digital micromirror devices (DMDs) are at the upper right. DMDs are known as successful examples in the MEMS market. In this way, fusion of MEMS with CMOS LSI will make the market larger and the integrated CMOS-MEMS technology is a promising way to achieve key devices for creating new markets.

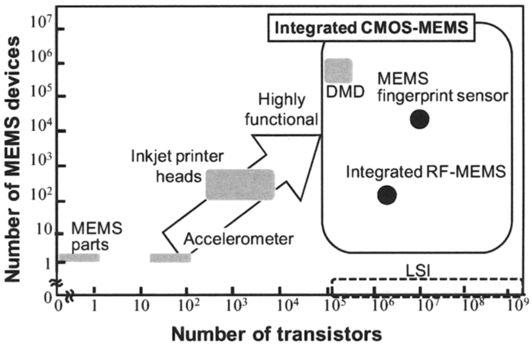

Fig. 1. Market trend and correlation between number of MEMS devices and transistors.

There are four features of the integrated CMOS-MEMS technology. 1) Single chip integration makes miniaturization and thinner units possible. 2) High functionality is achieved by CMOS LSIs controlling active MEMS devices; passive MEMS devices become active with signal processing. 3) High accuracy is obtained because the influence of the parasitic resistance and/or capacitance is greatly suppressed due to MEMS directly connected to CMOS LSI. 4) Mass-production is possible because the testing techniques used in LSI technology can be applied to CMOS-MEMS fabrication; MEMS function can be emulated by dummy function of LSI. Therefore, the integrated CMOS-MEMS technology is a promising way to develop high functional devices beyond CMOS scaling.

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