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Integrated CMOS-MEMS Technology and its Application

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1. Introduction

Fusion of microelectromechanical systems (MEMS) technology with CMOS LSI technology is a promising way to develop high functional devices. We have been developing the integrated CMOS-MEMS technology that fabricates MEMS devices on CMOSLSI. The technology has features of high-functionality, high-accuracy, and mass-production.

In this paper, first, MEMS technology trends and the concept of the integrated CMOS-MEMS technology are described. Next, we present the STP technology for the CMOS-MEMS technology. Finally, as the examples, we demonstrate the integrated CMOS-MEMS fingerprint sensor LSI[1] and the integrated RF CMOS-MEMS switch [2].

2. Integrated CMOS-MEMS technology

Prospects and challenges of the integrated CMOS-MEMS technology are described from the viewpoint of CMOS LSI. Figure 1 shows the correlation between the number of MEMS devices and transistors and it also indicates the business trends. Digital micromirror device (DMD) is on the upper right. DMD is well known as a successful example of MEMS business.

There are some kinds of method for fabricating the integrated CMOS-MEMS device. We propose the structure and process of the integrated CMOS-MEMS as shown in Fig.2. The technology compatible with CMOS LSI process gives the solution of developing high functional devices.

3. STP Technology

STP (Spin coating film Transfer and hot-Pressing) is a film depositing, planarization and sealing technology based on a new concept [3]. The concept is to spin-coat a base film with a dielectric and to transfer it from a base film to a wafer by hot-pressing in a vacuum as shown in Fig. 3. STP can realize the CMOS-MEMS devices.

4. Integrated CMOS-MEMS fingerprint sensor

We propose the MEMS fingerprint sensor as shown in Fig. 4. Each pixel has a protrusion, a cavity, a pair of electrodes on the sensing circuit and a grounded wall. The upper electrode and sealing layer are deformable thin films.

The important process in the MEMS structure fabrication is the sealing of a cavity to prevent contamination. This is performed by using STP. A pixel cross section obtained by a focused ion beam (FIB) is shown in Fig. 5. We compared the proposed sensor with a conventional capacitive fingerprint sensor. The proposed sensor can capture the fingerprint image as usual [Fig. 6(a)], while the capacitive sensor cannot [Fig. 6(b)]. These results indicate that the sensor is immune to the finger surface conditions and environmental conditions.

5. Integrated RF CMOS-MEMS switch

The conceptual structure of the integrated RF CMOS-MEMS switch is shown in Fig. 7. We fabricated an SP8T RF CMOS-MEMS switch. Eight RF MEMS switches were formed on a 0.6-μm CMOS LSI, which contained a 3-bit address decoder circuit and an IO circuit. Figure 8 shows a scanning electron microscope (SEM) photograph of the integrated RF MEMS switches. Figure 9 suggests that the encapsulated RF MEMS switch was formed on the CMOS LSI. The 3.3 V operation of the SP8T RF CMOS-MEMS switch was verified by transient measurements.

Therefore, the integrated RF CMOS-MEMS switch will be suitable for single-chip multiband RF transceivers.

6. Summary

The potentiality and the trend of the integrated CMOS-MEMS technology are described. As its applications, the fingerprint sensor and RF switch are presented.

In conclusion, it is confirmed that the integrated CMOS-MEMS technology will pave the way for the More than Moore technology.

Acknowledgments

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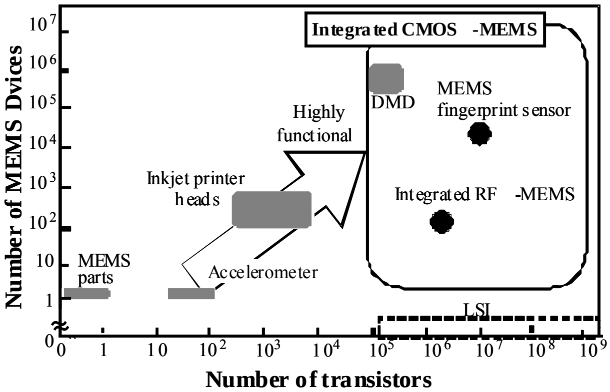

Fig.1. Business trend and correlation between the number of MEMS devices and transistors.

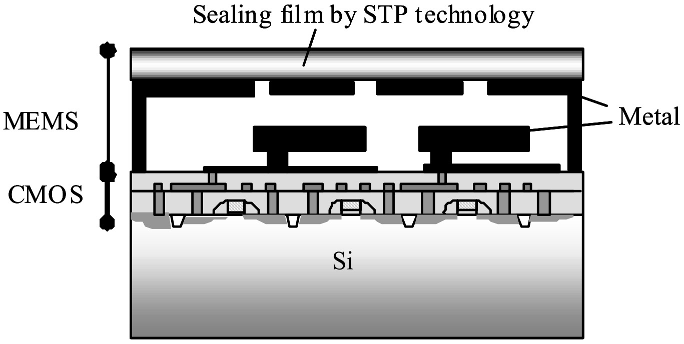

Fig.2. The integrated CMOS-MEMS device structure.

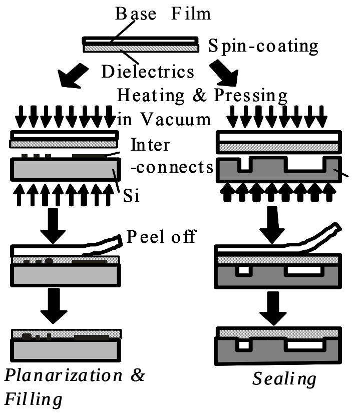

Fig.3. Principle of STP technology.

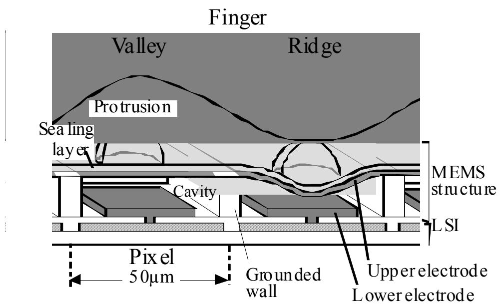

Fig.4. Structure and sensing mechanism of proposed MEMS fingerprint sensor.

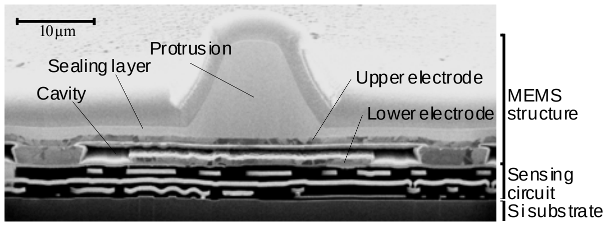

Fig. 5. FIB (Focused Ion Beam) cross section of the pixel.

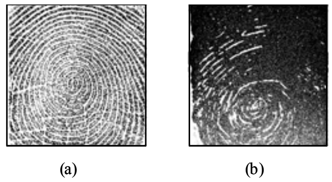

Fig. 6 Fingerprint images of a finger wetted with water captured by (a) the MEMS and (b) a capacitive fingerprint sensor.

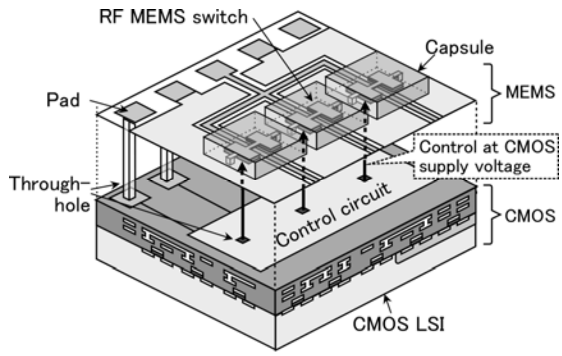

Fig. 7. Schematic of the RF CMOS-MEMS switch. RF MEMS switches are stacked on a CMOS LSI and controlled by a control circuit at the CMOS supply voltage.

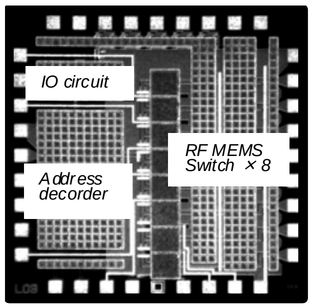

Fig. 8. Fabricated SP8T switch.

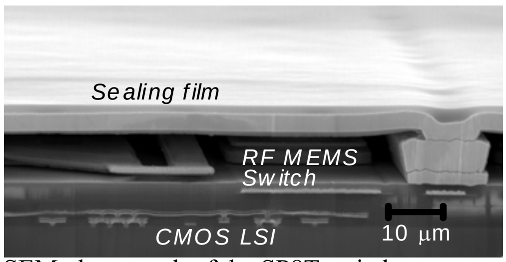

Fig.9 SEM photograph of the SP8T switch.