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Evaluation of ESD hardness of fingerprint sensor LSIs ☆

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Abstract

We evaluated the electrostatic discharge (ESD) hardness of capacitive fingerprint sensor large scaled integrated circuits (LSIs) with two kinds of ESD test methods.

We used three kinds of fingerprint sensor LSIs, i.e., a conventional planar sensor LSI, a sensor LSI with a grounded wall (GND wall) structure where each sensor plate was surrounded by a lattice-like wall, and a sensor where some of the sensor plates had been replaced with GNDs. In human body model (HBM)-based contact discharge tests, the sensor LSI with the GND wall structure and the one with the GNDs demonstrated a high ESD hardness compared with the planar sensor LSI. An air discharge test was also carried out in accordance with IEC61000-4-2 specifications because other ESD tests cannot be used to estimate over ± 8 kV. The ESD hardness of the GND wall structure was ± 20 kV, whereas that of the other sensor with the GND structure was below ± 12 kV. It was evident from our findings that the ESD hardness of sensor LSIs obviously depends on the number of GNDs in the sensor region, their arrangement, and the GND structure, and that the sensor LSI with the GND wall had the highest ESD hardness.

Keywords: ESD; HBM; Fingerprint sensor; Tolerance

1. Introduction

Personal authentication is a useful security measure for controlling access to secure areas, mobile equipment, and high-security computer systems. To achieve such purposes, a semiconductor capacitive-sensor chip for fingerprint identification is the most useful device because it has the simplest, most compact shape and provides one of the most reliable methods of authentication [1–5].

Fig. 1 is a block diagram of a capacitive fingerprint sensor large scaled integrated circuit (LSI). It is comprised of a pixel array, analog-to-digital converter, and other circuits. To capture a fingerprint image, the sensor measures the slight capacitance between the sensor plate and finger surface when the finger touches the surface of the sensor chip directly. Each pixel contains a sensor plate and sensing circuit. The sensing circuit detects the capacitance formed between the sensor plate and finger surface.

The surface of a capacitive fingerprint sensor LSI is likely to be exposed to high electrostatic discharge (ESD) from the finger just before or at the moment it touches, as we can see from Fig. 2. It is well known that the combination of synthetic fabrics and a dry atmosphere is especially favorable for the generation of static electricity. A person walking on a carpet can generate voltages higher than 15 kV.

All pins in an actual sensor LSI are shielded by packaging or the module, but the sensor region of a fingerprint identification module is exposed as can be seen from Fig. 3 [5]. When a person charged with static

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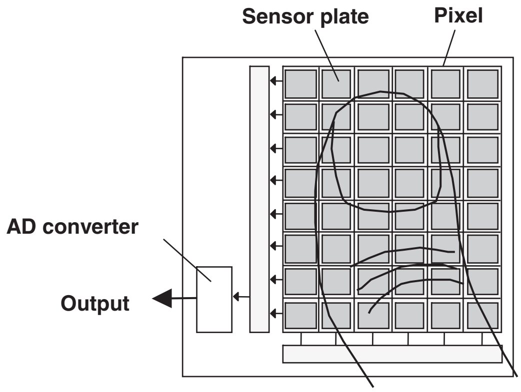

Fig. 1. Fingerprint sensor LSI.

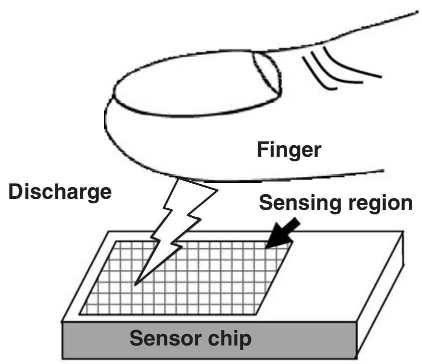

Fig. 2. Discharge from finger to sensing region for fingerprint sensor LSI during the process of fingerprint registration or identification.

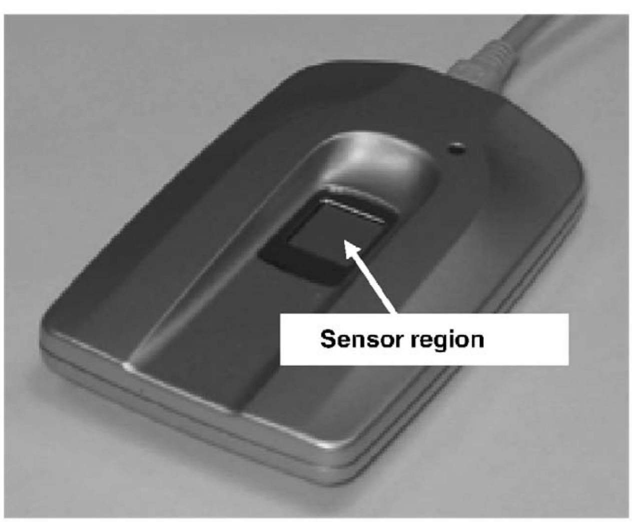

Fig. 3. Photograph of fingerprint identification module [5].

electricity touches a fingerprint sensor LSI for the process of fingerprint registration or identification, the resulting ESD could damage the sensor plate region.

Therefore, it is important that the ESD hardness of fingerprint sensor LSIs, especially that of the sensor plate region, be tested, assuming the worst possible user environment.

We investigated the relationship between the sensor structure and ESD hardness in detail in this study. First, we carried out a contact discharge test around the sensor plate based on the human body model (HBM). We then examined the ESD failure mechanism in a planar sensor LSI, evaluated the contact resistance of a sensor LSI with a grounded wall (GND wall), and that of another sensor LSI having a structure with GNDs. Finally, an air discharge test was performed on the sensor LSI with the GND wall and the one with the GNDs under ESD stress as high as 20 kV.

2. Samples and experiments

2.1. Sensor structure and fabrication

We fabricated a fingerprint sensor LSI with a GND wall and a conventional planar fingerprint sensor LSI [Fig. 4(a) and (b)] [6]. The GND wall structure, which acts as a current path for ESD, was formed after the sensing and logic circuits had been fabricated. Each sensor plate is surrounded by a lattice-like wall as we can see from Fig. 4(a). The GND wall was made of gold to ensure good finger contact and prevent GND oxidation. A thick polyimide layer was formed in the form of a hard passivation film after the GND wall was fabricated. The planar sensor LSI was fabricated using the conventional CMOS LSI process, starting with the sensing and logic circuits and ending with the deposition of a passivation film. To compare the sensor LSI with the GND wall with another of the same type, we also tested a commercially available sensor, where some of the sensor plates had been replaced with grounds [Fig. 4(c)]. We called this structure a planar-with-GND.

The chip characteristics of the three sensor LSIs are summarized in Table 1. We used 0.25 and 0.5 μm CMOS processes for the sensing and logic circuits of the sensor LSI with the GND wall. We used the 0.5 μm CMOS process for the planar one. We used the 0.35 μm CMOS process for the planar-with-GND. The pixel size was 50×50 μm for all structures. The number of GNDs equaled the number of sensor plates in the sensor LSI with the GND wall. However, the planar-with-GND only had 64 GNDs in the sensor region.

2.2. Experiments

2.2.1. Contact discharge test

Three models are generally used to describe ESD events that cause device failures. These are the human body, charged device, and field-induced models. In these, device failures are mainly caused by fabrication