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MEMS Packaging for RF switch

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1. Introduction

For MEMS devices, the packaging process provides the mechanical and environmental protection for the three-dimensional mechanical structure and actuators during wafer preparation, chip assembly and actual use. Especially for RF MEMS, including RF switch, the packaging of movable and fragile mechanical parts in a clean and stable environment is serious issue in order to maintain the performance by avoiding problems like the signal resonance reflection.

Recently, various techniques of wafer level packaging for RF MEMS devices were proposed [1-5]. Among those, we selected frit glass bonding method. The reasons of the choice are the low cost process and the contamination-less material composition with inorganic material. And also, this method is reliable because it is commonly used for commercial MEMS sensors, such as MEMS accelerometer.

In this paper, this frit bonding method which is adopted to wafer level packaging of RF MEMS switch and the device fabricated with this method are described.

2. Wafer Level Packaging for RF MEMS Switch

Structure of RF MEMS Switch

The schematic structure of RF MEMS switch is shown in Figure 1 [6]. RF MEMS switch consists of three substrates. The base substrate is a glass substrate with through-holes made by sand blast. The diameters of each through-hole are 250μm on the topside and 600μm on the backside. The surfaces of the through-hole are metalized to connect the transmission line with the electrodes at the bottom. Spray coating of resist is used for patterning the metal films sputtered on the wafer with through-holes. The base substrate has CPW transmission line on the topside. And also, on the glass substrate, the input and output signal lines are taken out from the backside. Those lines are connected to a circuit board with the bumps on the electrodes on the backside of the switch itself.

The movable substrate consists of single crystal silicon actuators. The movable contact is formed on the insulating layer underneath the silicon actuator. Meanwhile, the fixed contact is formed on the top of the signal lines. The silicon substrate is bonded to the glass substrate with two anchors and comprises a movable electrode and a restoration spring.

The wafer level packaging is done with a cavitied glass wafer as cap and frit glass as sealant.

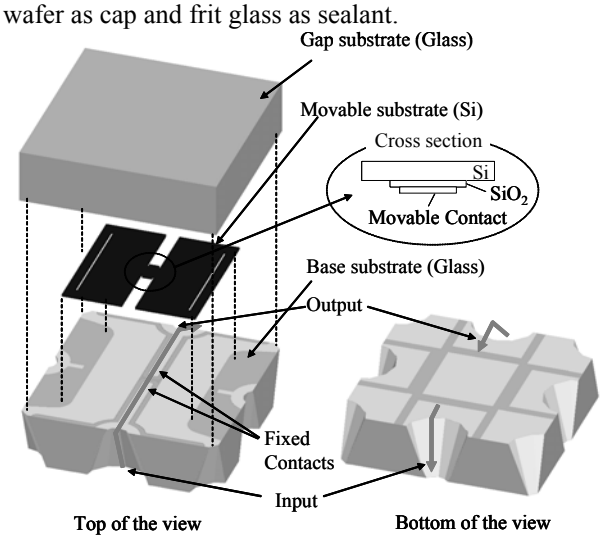


Figure 1 Schematic structure of RF MEMS Switch.

And after all, the chip the bonded wafers are diced to free each chips.

Processes of Wafer Level Packaging

The cap (packaging) wafer is bonded to the device wafer after screen printing and grazing of frit glass. The main material for frit glass bonding is low temperature melting glass. The width and thickness of the bonding line are 250μm and 10μm. The frit glass bonding process applies force of 5000N on a 4in. diameter wafer and temperature of 450℃ for 30 minutes. The inside of the cavity is replaced with inert nitrogen gas and decompressed.

Figure 2 shows the top view of a part of the MEMS switches wafer and Figure 3 shows the photograph of the CSP (Chip Scale Package) type RF MEMS switch. The size of each RF MEMS switch is 1.8 x 1.8 x 1.0 mm^3. This RF MEMS switch has been fabricated for up to 10GHz operation using a 50Ω coplanar waveguide (CPW) line on a glass substrate and with through-holes. The wafer level packaging and metalized through-holes makes it possible to mount the device chip directly on the circuit board without any extra outer packaging and wire bonding, which may deteriorate the RF characteristics.

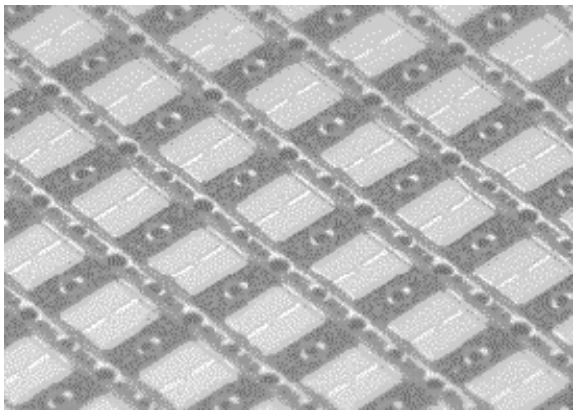
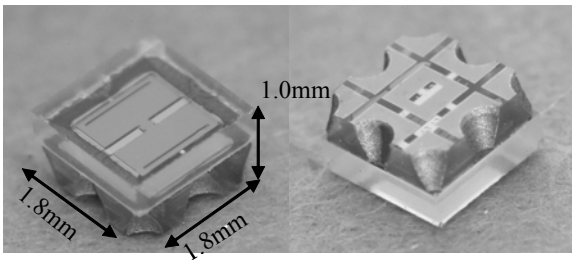


Figure 2 Top view of part of 4-inch wafer after wafer level packaging.



Top of the view Bottom of the view

Figure 3 Photograph of the CSP type RF MEMS switch.

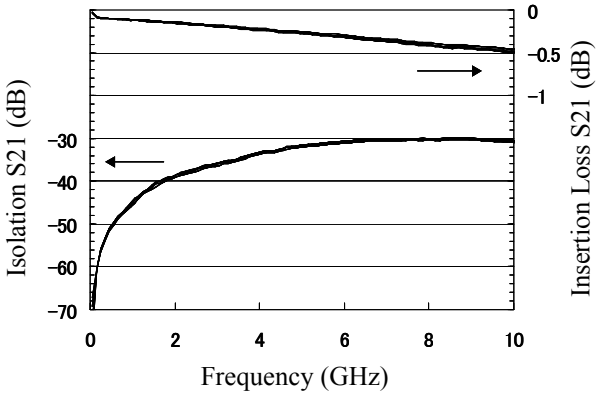


Figure 4 Measured S-parameters for CSP type RF MEMS Switch.

Figure 4 shows the RF characteristics of the fabricated RF MEMS Switch without outer packaging. S-parameters of the RF characteristics are measured with 8722ES Network Analyzer (Agilent Technology) with 650μm pitch Air Coplanar™ Probe (Cascade Microtech). On the broadband from 0.05 to 10 GHz, it showed superior characteristics, such as the insertion loss less than -0.5 dB and the isolation more than -30 dB.

3. Conclusions

We have successfully demonstrated RF MEMS devices which is capable of practical operation at up to 10GHz with wafer-level packaging process by frit bonding method.

We will continue our R&D efforts to pursue technological potential of RF MEMS devices and to realize further advanced RF MEMS devices for use in communications and measuring applications, where the demand for RF devices is growing.

Acknowledgements

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