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MITSUBISHI ELECTRIC ANNOUNCES RF-MEMS SWITCHES FOR HIGH FREQUENCY CIRCUITS

Tokyo, February 15, 2005 – Mitsubishi Electric Corporation (President and CEO: Tamotsu Nomakuchi) announced today micromachined high-frequency RF-MEMS*[1] switch that selects the through and open states. The switch realizes route-switching circuits that show flat and low loss performance over very wide frequency range from 0 to 100GHz. The circuits are effective for miniature and high performance wireless equipments such as phased array antennas, tunable filters, and millimeter-wave wireless LANs.

A miniature RF-MEMS switch for low frequency applications is also presented. The switch adopts all metal structure and its metal beam works as the actuating electrode as well as the signal line. Mobile terminal equipments or wireless LAN systems, which require high-density integration, could utilize the switch.

*[1]: RF-MEMS: (Radio-Frequency Microelectromechanical Systems)

Background and Abstract

The RF-MEMS switches are expected to be the key devices of the future wireless communication because of its low insertion loss compared to conventional switch that uses FETs[*2] or diodes, and its low production cost.

We have already presented RF-MEMS switches that select the through and short-circuited states. Now, we present the new RF-MEMS switch that selects the through and open-circuited states. Combining it with the through and short-circuited type ones, high-performance and miniature route-switching circuits would be obtained. Since the switches of both types are fabricated by the same process as the DAM[*3] structure, the functional RF circuit that includes these RF-MEMS switches and other elements is easily integrated and is able to reduce the cost and the size.

A miniature RF-MEMS switch for low frequency applications is also developed by adopting the common actuating electrode with the signal line.

*2 FET: Field Effect Transistor

*3 DAM: Dielectric-Air-Metal, Our developing micromachined hollow structure for RF circuits

Main Features

1. **RF-MEMS switch for high-frequency-band route-switching circuits**

   We have developed the new RF-MEMS switch that selects the through and open-circuited states. Separating the actuating electrodes from the signal line to reduce transmission loss at high frequency, low insertion loss and high isolation characteristics are obtained in wide frequency range from 0 to 100GHz. Combining it with the now-developed through and short-circuited type ones, the leaked signal current would reduced to less than –40dB, then high-performance route-switching circuits or tunable impedance circuits would be obtained.

2. **A compact RF-MEMS switch for low-frequency applications**

   For the applications of the frequency-band less than 6GHz such as mobile phone or wireless LAN, a miniature RF-MEMS switch is developed. Adopting the high-speed sacrificial etching technique that utilizes metal corrosion reaction, the organic residuum that degrades conductivity at the contact parts, is removed. The all-metal structure also makes the signal line be the actuating electrode at the same time. Then, the length of the switches could be reduced to 0.15mm and this is one tenth of the area of our previously developed MEMS switches.

Future Developments

We will develop miniature wireless communication modules, and will apply them to productions of RF sensor modules or millimeter-wave phased array antenna.

Results

1. **Structure and characteristics of the through and open-circuited states MEMS switch**

   Figure 1 shows the structure and motion of the switch. Voltage applied between the co-planar ground and the bottom ground actuates the silicon-nitride membrane down to the bottom to make contacts of the signal lines. Figure 2 shows the scanning electron microscope image of the switch. A low-insertion loss, and high isolation performance from DC to 100GHz has been achieved as the measured results shown in the figure 3.

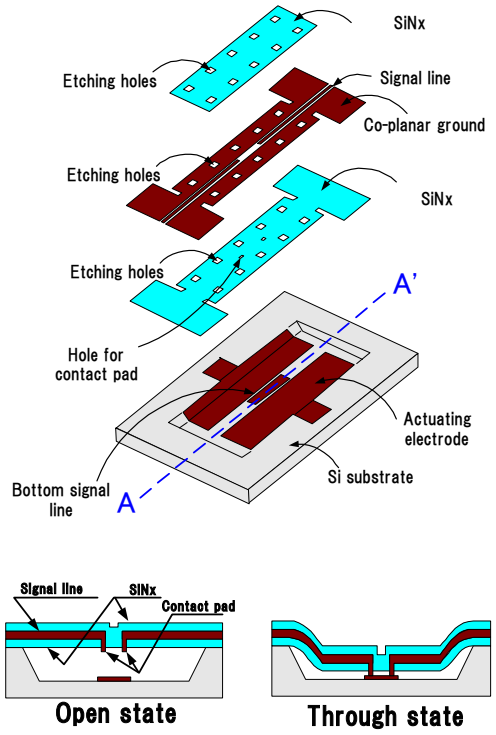

Fig.1 Structure and motion of the switch

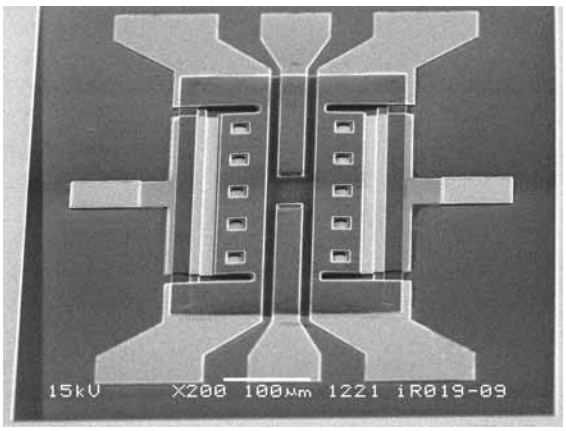

Fig.2 SEM image of the switch

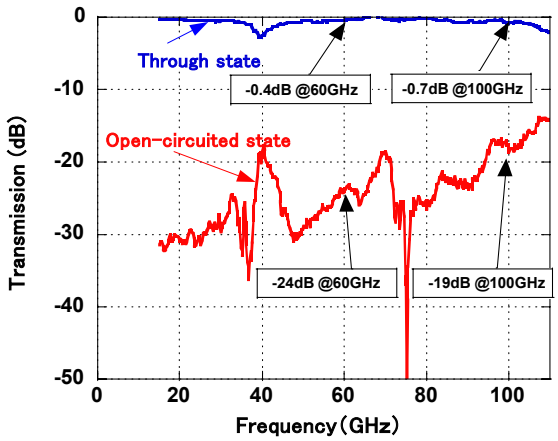

Fig.3 Measured results of the switch

2. Route-switching circuits

Figure 4 shows a route-switching circuit using only the through and short-circuited states switches. When the switch has the isolation of –20dB, the leak signal current at the port B is –20dB. The quarter-wave-length line is required to pass the signal into the port A. Figure 5 shows a route-switching circuit using only the newly developed through and open-circuited states switches. The quarter-wave-length line is not required, but the isolation is still –20dB. Figure 6 shows a route-switching circuit using both kinds of the switches. No quarter-wave-length line is needed and the

isolation is improved to –40dB. Combination of the two kinds of switches realizes compact and high performance route-switching circuits.

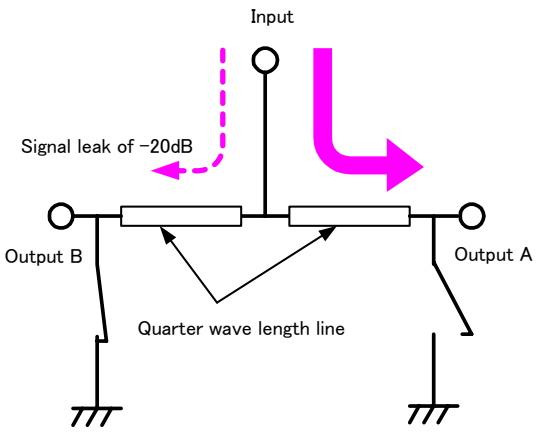

Fig.4: a route-switching circuit using only the through and short-circuited states switches.

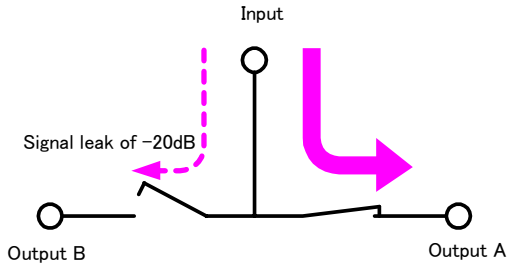

Fig.5: a route-switching circuit using only the through and open-circuited states switches.

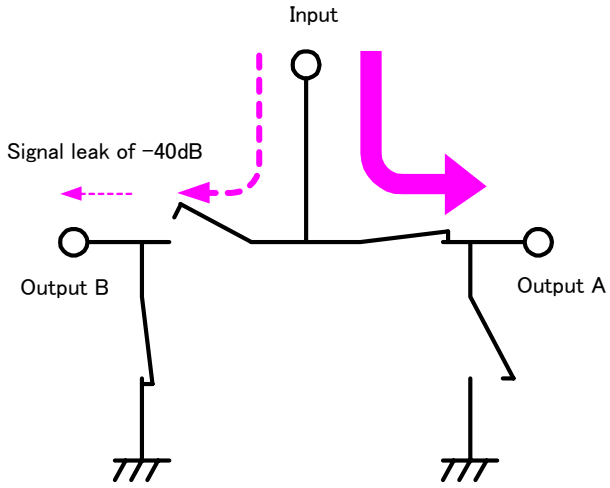

Fig.6: a route-switching circuit using both kinds of the switches

3. Compact RF-MEMS switch for low-frequency applications

The compact all-metal structure uses the signal line as the actuating electrode as well. Then, the total area of the signal transmission and the actuating structure is reduced to one tenth of the area of our previously developed MEMS switches. The switch length is 0.15mm.

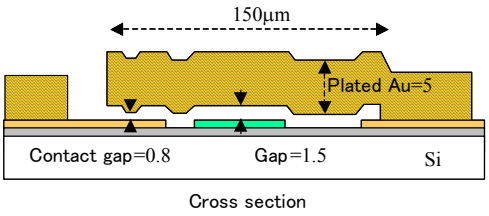

Fig.7: Cross-section of the compact switch

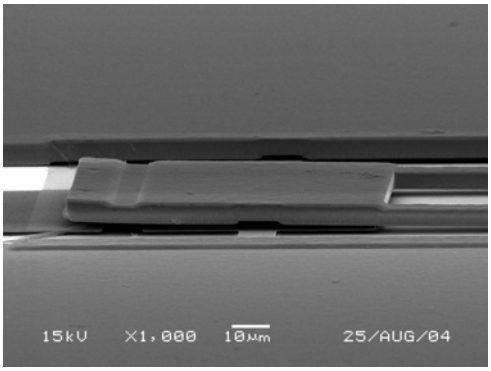

Fig.8: SEM image of the switch

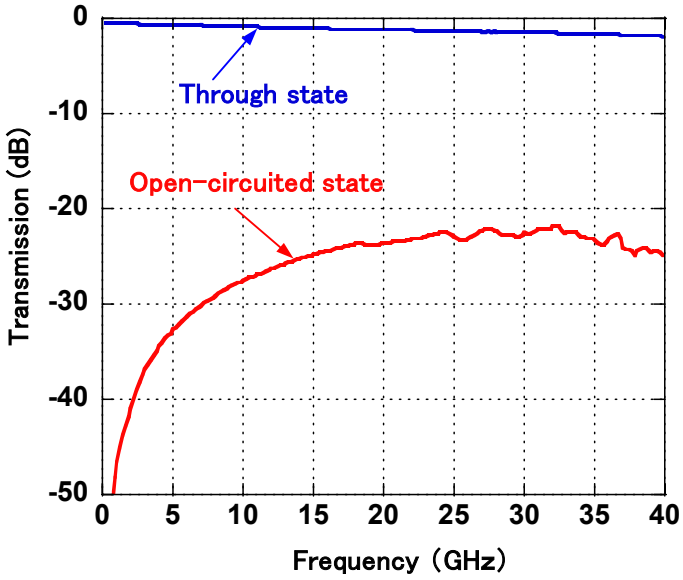

Fig.9: Measured results of the compact switch

About Mitsubishi Electric

With over 80 years of experience in providing reliable, high-quality products to both corporate clients and general consumers all over the world, Mitsubishi Electric Corporation (TSE:6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. The company recorded consolidated group sales of 3,309 billion yen (US$ 31.2billion*) in the fiscal year ended March 31, 2004. For more information visit http://global.mitsubishielectric.com

*At an exchange rate of 106 yen to the US dollar, the rate given by the Tokyo Foreign Exchange Market on March 31, 2004.