# Test method of frequency response based on diamond surface acoustic wave devices*

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In order to reduce the noises affixed to the signals when testing high frequency devices, a single-port test mode ($S_{11}$) is used to test frequency response of high frequency (GHz) and dual-port surface acoustic wave devices (SAWDs) in this paper. The feasibility of the test is proved by simulating the Fabry-Perot model. The frequency response of the high-frequency dual-port resonant-type diamond SAWD is measured by $S_{11}$ and the dual-port test mode ($S_{21}$), respectively. The results show that the quality factor of the device is 51.29 and the 3 dB bandwidth is 27.8 MHz by $S_{11}$-mode measurement, which is better than the $S_{21}$ mode, and is consistent with the frequency response curve by simulation.
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The mobile communication system develops very quickly in recent years. To resolve the problems of frequency segment hustle and effective utilization of frequency band in mobile communication system, and to push forward the high frequency development of mobile communication, diamond surface acoustic wave devices (SAWDs) with GHz center frequency become one of the important research focuses in the world[1-4].

How to exactly measure the frequency response of SAWD with high frequency has become the focus of this aera recently. Fig.1 shows the test principle of dual-port SAWD. Its frequency response is tested by $S_{21}$ (That is, the stimulant signal produced by the network analyzer is loaded in the interdigital transducer 1 (IDT1) of the input port, and the interdigital transducer 2 (IDT2) of the output port is connected with the signal processing unit of the network analyzer). Therefore, $S_{21}$ must be connected with the ch1 and ch2 of the network analyzer[5,6]. In research and development process of high frequency diamond SAWD, because of incomplete package, the parasitical problems have arisen when testing, and various transient interferences affect the accuracy of device analysis and design[7].

In this paper, in order to decrease the number of connection ports between the device and analyzer and to acquire more accurate frequency characteristics, a single-port test mode ($S_{11}$) instead of traditional double port test mode ($S_{21}$) is used to measure the frequency response of high-frequency double-port surface acoustic wave devices (SAWDs).

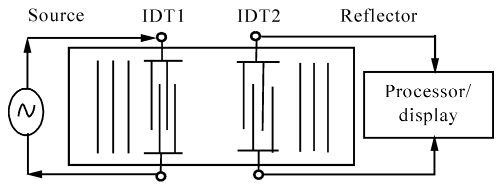


**Fig.1 Test principle of the dual-port SAWD by $S_{21}$**

The output IDT2 of the double port SAWD can be equivalent to the reflective grid array without signal output, so the SAWD can be regarded as a single-port SAWD (tested by $S_{11}$), that is, the IDT1 is connected with the stimulant signal produced by the network analyzer and the signal processing unit, as shown in Fig.2. Using $S_{11}$ only needs one channel of

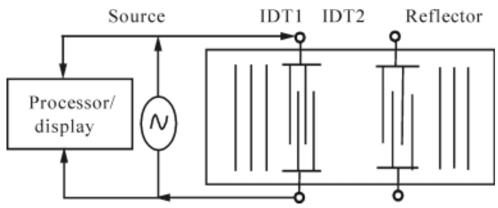


**Fig.2 Test principle of the single-port SAWD by $S_{11}$**

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the network analyzer, decreases correct steps, and acquires more accurate frequency characteristics.

In order to prove the feasibility of the proposed method, the Fabry-Perot model[8] is used for simulation. Fig.3 shows the Fabry-Perot model of the double-port SAWD. The resonance cavity is between the two reflective grids, whose length is the distance (2*L*) between the two grids. Frequency response of high frequency resonance SAWD can be simulated by the model of coupling theory[7,9,10], where the IDT parameters are the interdigital logarithm of 30, the aperture length of 680 μm, and the interdigital width of 1.7 μm. The simulated results are shown in Fig.4. The center frequency is 1.4 GHz, and the 3 dB bandwidth is 30 MHz.

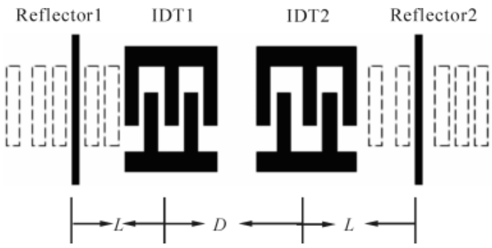


**Fig.3 Fabry-Perot model of the dual-port SAWD**

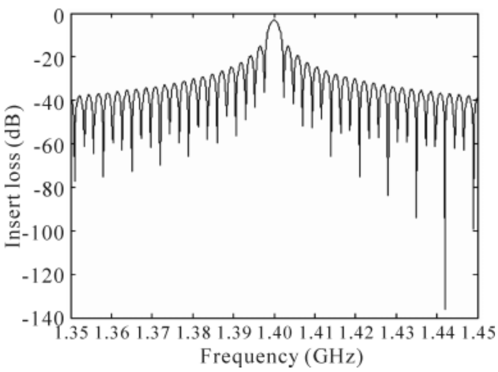


**Fig.4 Simulated frequency response of the dual-port resonance SAWD**

High frequency and dual-port resonance SAWD is tested by the Agilent E5070B/E5071B network analyzer. Fig.5 shows the results tested by $S_{11}$ and $S_{21}$, respectively. The quality factor *Q* is 51.29 tested by $S_{11}$, and that is 29.56 tested by $S_{21}$.

It is analyzed that there are input and output ports by $S_{21}$ test. It's difficult for network matching. Part high frequency impure waves would be introduced from the output port, the outside energy loss caused by bulk acoustic wave (BAW) isn't able to be restrained effectively, and *Q* is decreased. However, when using $S_{11}$ test, the input and output ports are the same one, and the output IDT is combined with the reflective grid, which can avoid to introduce too many high frequency resonance waves, restrains the BAW, and acquires the relatively accurate *Q* value.

Between the frequency response diagram tested by $S_{11}$ (Fig.5(a)) and the simulated one (Fig.4), there is good consistency in outside wrapping. Fig.5 shows that the 3 dB bandwidth of frequency response tested by $S_{11}$ is 27.8 MHz, while that tested by $S_{21}$ is 54.3 MHz. The former has better frequency band selectivity, better restraint from side lamella, and less frequency disturbance.

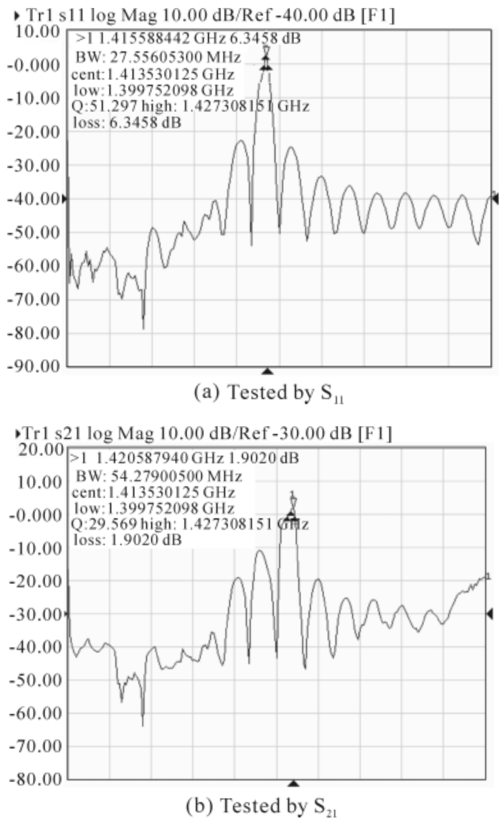


**Fig.5 Frequency response test diagram of the dual-port resonance SAWD through the Agilent E5070B/E5071B network analyzer**

In this paper, to realize frequency response test of high frequency and double port diamond SAWD, $S_{11}$ instead of traditional $S_{21}$ is used to decrease the number of connection ports between the device and analyzer. The method is feasible by theoretical analysis. Test results indicate that the 3 dB bandwidth of frequency response tested by $S_{11}$ has better frequency band selectivity, better restraint from side lamella, and less frequency disturbance than that tested by $S_{21}$. At the same time, the frequency response diagram and the simulated diagram have good consistency in outside wrapping. So it has good accuracy and stability to use $S_{11}$ for testing high frequency SAW sensors.

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