Characteristics of two types of mems resonator structures in SOI applications

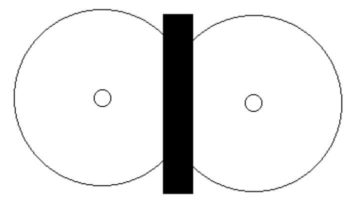
S. Myllymaki, E. Ristolainen, P. Heino, A. Lehto, K. Varjonen
Tampere University of Technology, Institute of Electronics
P.O.Box 692 FIN-33101 Tampere FINLAND
Tel. +358 3 3115 11 (university switchboard) Fax. +358 3 3115 2620
smy@ele.tut.fi

Silicon on insulator RF CMOS have got a lot of attention in the past. In the RF SOI technology the key factors are thickness of the silicon film and the thickness of the SO_2 insulator layer. The high mass resonator needs several micrometers of thickness and RF transistor needs about 100 nanometers of thickness. 100nm has selected to be maximum in this research.

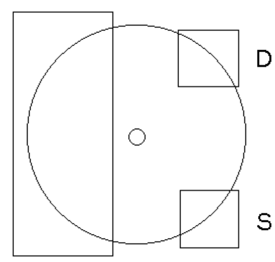
One possible solution to produce low-mass resonators is circular mode resonator, which is attached to solid SOI structure in its edges and which circles´s center vibrates freely and vertically. This kind of resonator is produced by controlling the radius of the circle, which makes it feasible for quality controlled mass production. From the filter point of view the conducting method between resonators is important. The circular resonator can be placed partly on the top of other resonator so that resonator are conducted each other by mechanical forces. Conducting rods will became useless in circular resonators. Moreover, the circular resonator can be adjusted to film thickness of 10nm to 1um. More important thing is the thickness of SO_2 insulator, because it defines the gap between electrodes. The development of SOI circuits evaluates thicknesses from 100nm to 10nm. At 1 GHz 10 V voltage will cause a relative shift in mechanically balanced point. The shift is presented in Table 1, column 1. Secondly, a corresponding relative shift in mechanical resistance is presented in column 2. Results have been got by commonly known formulas in mems resonators, but it is important to know real parameters in these physical dimensions. One possible way of manufacturing these resonators is to use little etching hole in the center of the chamber. In between resonators is weakly conducting area in order that main conducting mechanism between resonators is mechanical. Advantages for the structure are a solid film mounting, missing conducting rod and missing supporting elements. Also it is easy to produce itself, and it is compatible with other RF SOI circuits.

More advanced circular resonator is mechanically similar than previous structure. The difference is semiconductive wells placed to very close to resonating film so that formed transistor channel is actuated by changing capasitance. The structure is rather new and in principle, driving electrode can be isolated from drain and source with electric-mechanic -transformer. Also Id/Vg –ratio can be increased with using both direct electrical (gate voltage affects to channel) and undirect mechanical (gate voltage affects to gap between channel and substrate). Of course, the transistor can be driven only by undirect way too. Related ratio is same as direct / undirect –ratio.

In 10MHz frequency, for instance for oscillators, the related ratio will be nearly 1. So, it´s possible to use mechanical resonance as driving mechanism to transistor channel in lower frequencies. Of course it can be used alone or together with normal electrical driving in transistor. In this example the result has been calculated by 12µm of diameter of circle with 10/1 (dc/ac) voltages.



Picture 1. Resonator structure can have two chambers with electrically passivation area (seen on the top)



Picture 2. Basic mechanically driven transistor has at least one electrode to vibrate and normal drain, source electrodes (seen on the top)

Table 1:

Gap (nm)	Gap Shift(%)	Resistance (relative)	Related ratio
100	0,007	100	1 / 6600
75	0,016	32	1 / 765
50	0,053	6	1 / 230
25	0,422	0,4	1 / 100