

Applying MEMS Technologies to Frequency Control Devices

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Abstract

In the past four decades, the progress of integrated circuits technology follows closely with Moore's law – the numbers of the transistors double every two years. This progress makes modern electronic products smaller, faster, lower power, more functions, and cheaper. However, frequency control and timing devices, which represent the heartbeat of all electronic systems, have not been able to follow the same law. Therefore, miniaturization and integration of frequency control devices have always been one of the major challenges for system designers.

Conventional machining technologies such as grinding, polishing, and cutting have shown their limit on processing smaller and smaller traditional frequency control devices. Fortunately, with the progress of Micro-Electro-Mechanical Systems (MEMS) technology, which is like 3D extension of planar semiconductor processes, researchers and engineers start to use MEMS as a tool to shape mechanical devices for frequency control and timing applications. Although Silicon and polysilicon are of course the easiest materials to process, MEMS process has extended its application to metal, piezoelectric films, and even quartz crystal blanks. Even the debate between silicon MEMS versus quartz are heated, eventually both of silicon and quartz need MEMS technologies to obtain competitive advantages.

This tutorial provides a MEMS toolbox for researchers and engineers in frequency control industry. This toolbox consists of two categories: (1) Micromachining technologies: including recent progress in MEMS process technologies, wafer level packaging, and through silicon/quartz via, and wafer bonding technologies. I think MEMS technologies will be widely used in frequency control industry, no matter what materials are going to dominate; (2) Designs of miniaturized resonators and their limits: we will use several MEMS based devices, including electrostatic driven resonators, piezoelectric resonators, and micromachined quartz crystals as examples.