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Flow-Injection-Based Miniaturized Quartz Crystal Microbalance

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In this research, we present the design and realization of a flow-injection-based high-fundamental-frequency (HFF) quartz crystal microbalance (QCM) sensor. A well-known fact is that increasing the fundamental frequency of thickness-shear-mode (TSM) QCM would result in an increase in mass sensitivity when it is used as chemical sensors or biosensors. HFF QCM is designed and fabricated on a small 4 × 4 mm^2 AT-cut quartz crystal chip using an inexpensive wet etching process with an inverted-mesa structure. For actual applications in liquid, a flow-injection-based QCM system is established, which is composed of a syringe pump, a sample injector, and a custom-made microflow cell. HFF QCMs are achieved by decreasing the central area thickness of a quartz wafer, which is inversely proportional to the vibration frequency. The vibration characteristics of fabricated QCM chips, including resonance frequency, quality factor (Q value), and equivalent circuit parameters, are measured using an impedance analyzer 4294A. HFF QCMs with high Q values of up to 29000 for 52 MHz in air were achieved. Even if assembled into the custom-made microflow cell, QCMs show a Q value beyond 23000 as measured using an impedance analyzer. These results demonstrate the successful design and fabrication of the flow cell, which does not degrade the performance of the QCM resonator. A Q value as high as 1000 of HFF QCM was observed even when pure water is flowed through the chip surface, which clearly demonstrated that the fabricated QCM and flow cell system could be used in liquid.

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