INTRODUCTION

In this document we want to describe the quartz tuning fork(QTF) biosensors and explain the relationship between QTF and QCM biosensors. This document does not include information about F-Master and Q-Master biosensor measurement systems. For more information about F-Master and Q-Master please refer to the relevant brochures and user manuals.

WHAT IS MASS SENSITIVE BIOSENSOR?

Mass sensitive biosensors based on collecting target molecules on the sensor structure and detecting them. Generally, sensor surface previously modified to collect molecules selectively. These sensors mostly made of piezoelectric materials such as quartz. The sensor structure has a resonance frequency. This is the natural vibration frequency of the sensor. When the sensor surface exposed to the target molecule, the resonance frequency will shift to another frequency. The shift amount is proportional to the amount of the mass collected. If we can measure the frequency shift then we can understand that the target molecule is exist. This is the basic idea behind the mass sensitive biosensors.

The best known mass sensitive biosensors are QCM biosensors. These are made of quartz crystal disc that sandwiched between two golden electrodes. This structure has a unique resonance frequency. One of the golden electrodes surface could be modified in several way to make a molecule selective surface. When the surface begin to collect the molecules, a frequency shift will occur. This shift (as mentioned before) is the basic of the measurement.

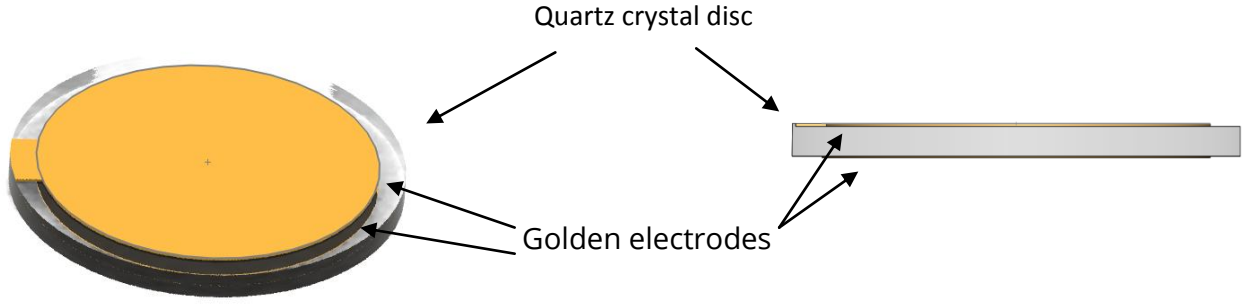

Figure 1: The structure of the QCM chip.

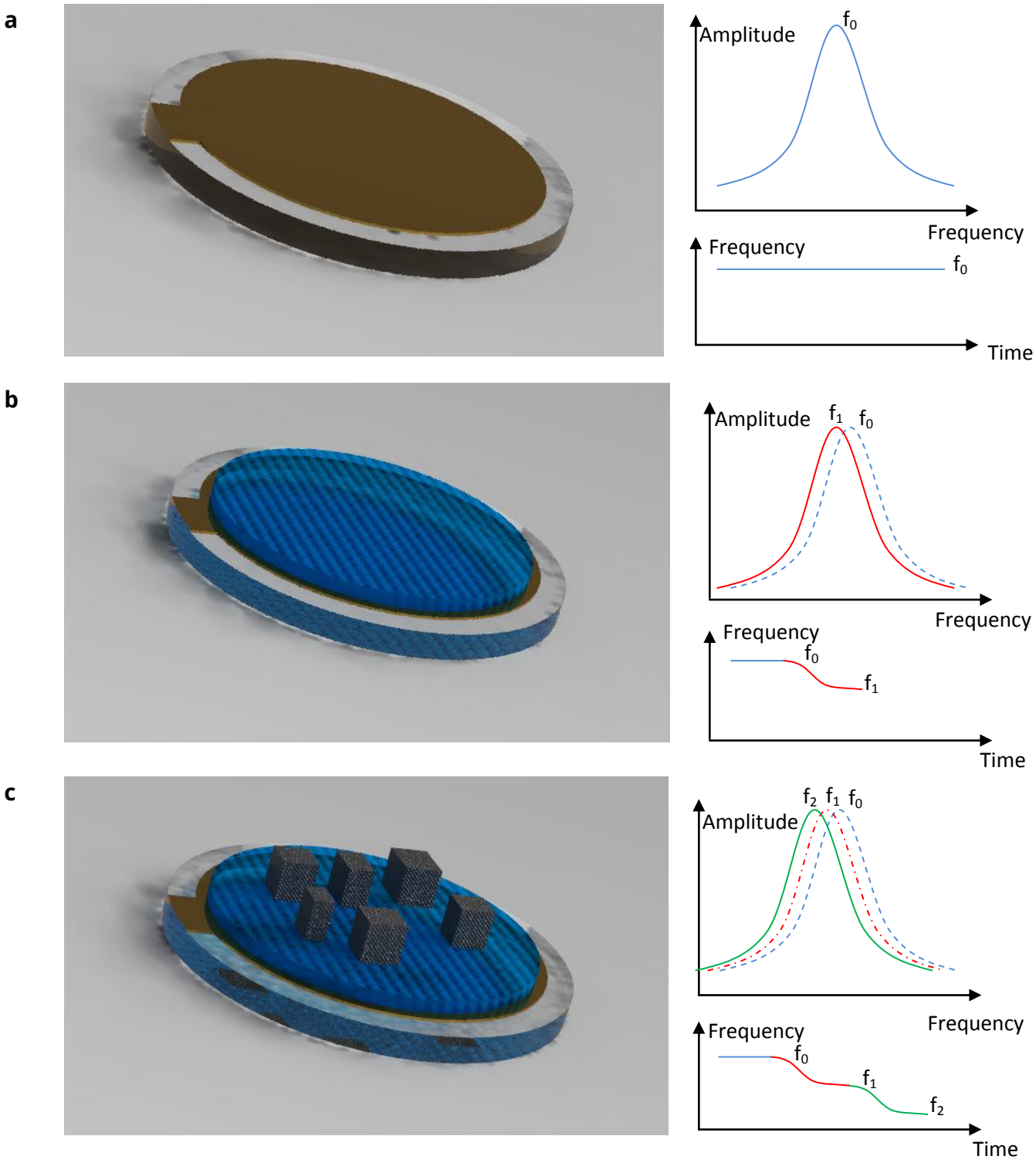

Figure 2: The illustration of the stages of QCM experiments. **a)** QCM chip has a natural oscillating frequency f_0. **b)** After modifying the surface to have a selective surface you will have a layer of selective surface material. This has a mass. So it will cause to a frequency shift as shown in the graph as f_1. **c)** When the sensor exposed to the target molecule the molecules will be collected at the surface. This additional mass will cause to another frequency shift. The final frequency is f_2.

WHAT IS QTF BIOSENSOR?

QTF stands for *quartz tuning fork*. This structure was invented by watch industry to provide a sensitive clock signal. QTF is used widely in the electronic industry. It is mass produced. Thus QTF is a very low cost alternative to the QCM biosensors. It has a very high quality factor which is over 10000. This is also made of quartz crystal. It plated with metal electrodes. Its shape is as shown below at figure 3.

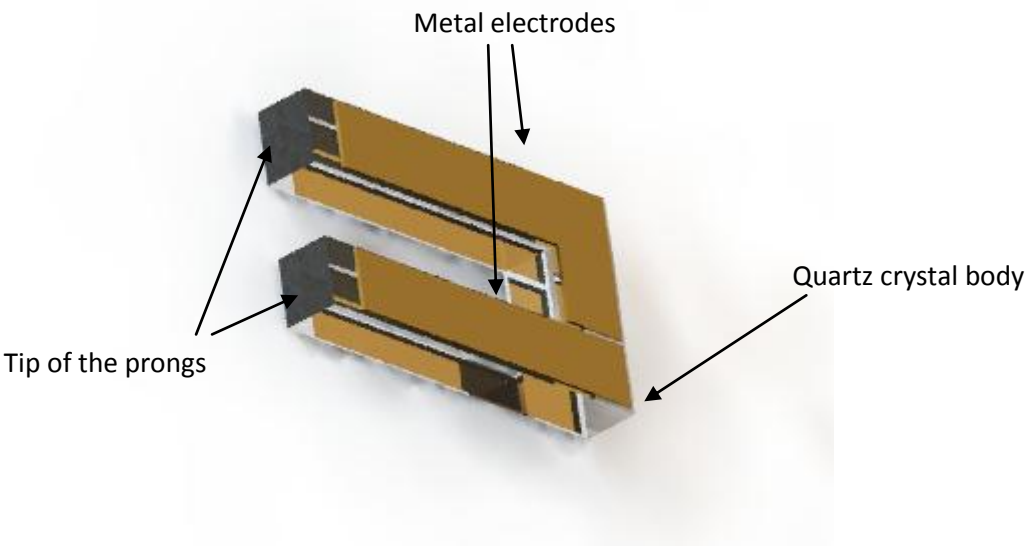

Figure 3: The structure of the QTF.

It has also a natural resonance frequency. Its surface can be modified to make a molecule selective surface. Following a very similar procedure to QCM you can make biosensors. There are several publication about QTF biosensors. But there wasn't any device developed particularly for QTF biosensor measurements previously. Experiments mostly made with atomic force microscopes, sophisticated electronic circuits or some setup that consist of signal generator, oscilloscope and simple circuits.

THE RELATION BETWEEN QTF AND QCM

QTF and QCM are both kind of resonator. Both made of piezoelectric quartz material and coated with metallic electrodes. QCM works at MHz frequency range while QTF works at kHz range. QCM developed especially for scientific researches while QTF is a mass produced component mostly used in electronic industry. Thus QTF much lower cost than QCM. This is about $100 for QCM and $0.03 for QTF. The quality factor or Q-factor is a kind of the measure of sensitivity. This is in the range of a few hundred to a few thousand for QCM while about 10000 for QTF. This makes QTF much more sensitive than QCM. We need this sensitivity because QTF has much less surface area than QCM. This means you can't collect molecule on the surface of the QTF as much as QCM. Higher quality factor of the QTF compensate this disadvantage and in some cases goes

beyond. You can use QCM with o-ring on the bottom of fluidic cell. In this arrangement we can assume that the QCM fully immersed in the liquid.

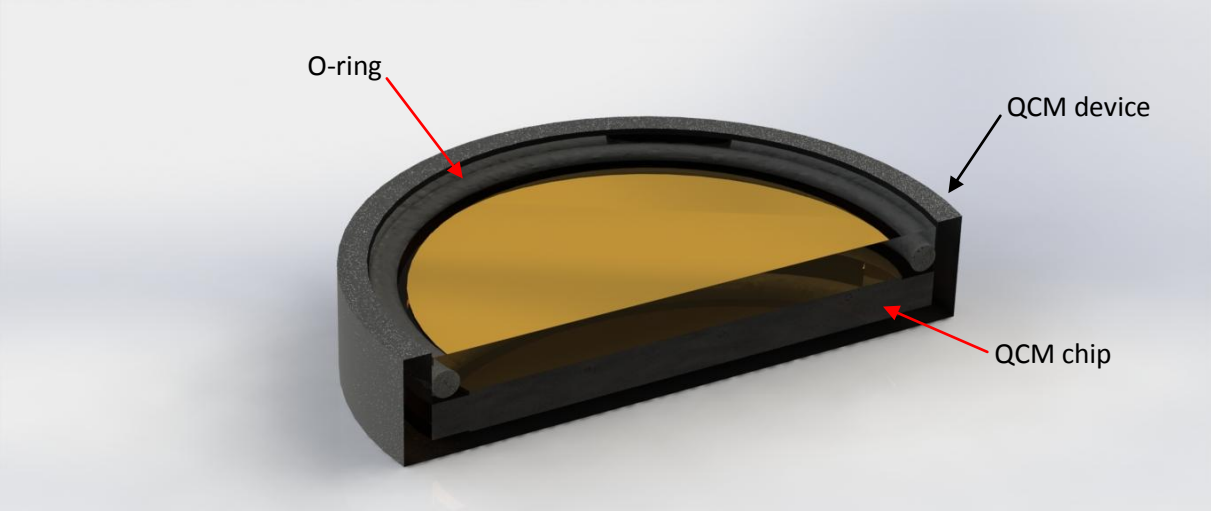

Figure 4: QCM immersed in liquid.

But you can't fully immerse the QTF in the liquid. Because in this case both electrode (negative and positive) of the QTF will be exposed to the liquid. If the liquid is conductive this will cause to a short circuit. To make experiment with QTF you have to use the tip of the prongs and avoid immersing the rest of it.

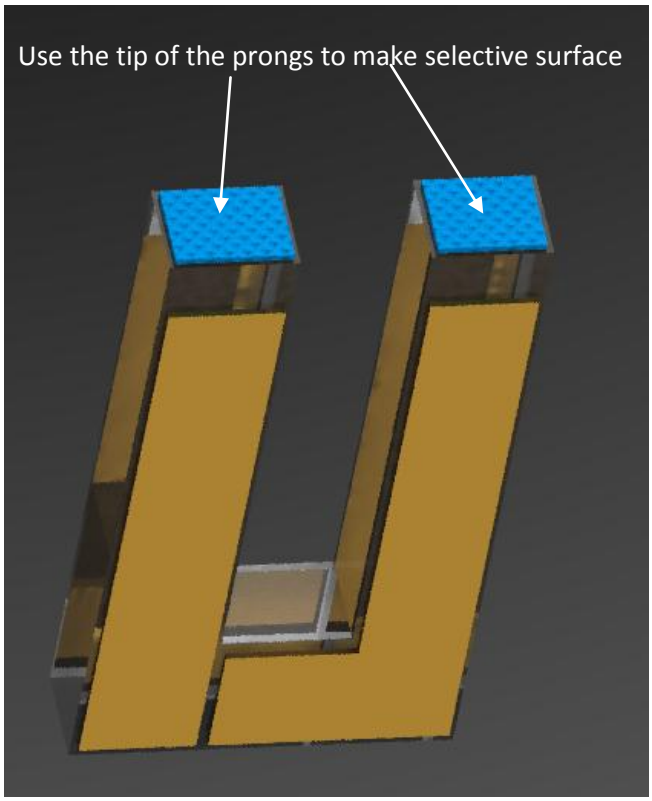

Figure 5: Best part of the QTF to modify is the tip of the prongs.

Because the electrodes are placed there. This kind of experiments will require an alignment equipment. This is one of the difficulty of QTF experiments.

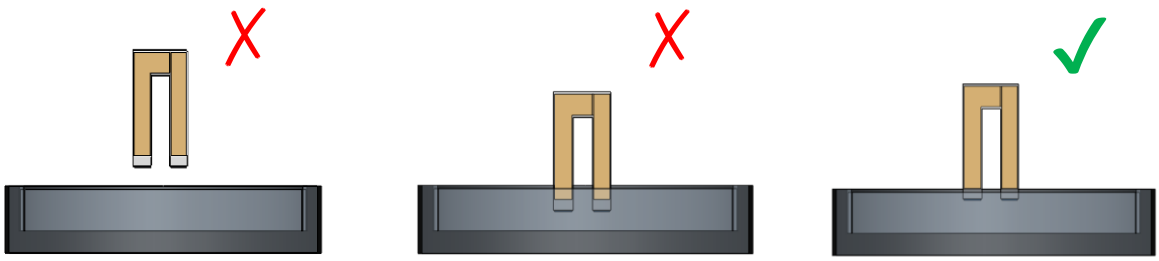

Figure 6: Proper way of working with QTF biosensor.

If you want to design a biosensor with QTF you can follow the way of designing QCM biosensors. But there is a big difference. When you are working with the QCM you have a metallic (golden) surface to modify. This surface is the surface that active or sensitive to the target molecule. On the other hand when you are designing a biosensor with the QTF the surface is quartz crystal. This basic difference will effect your design. The molecule that thought to be used to modify the golden surface of the QCM may not be appropriate to be used in the quartz surface of the QTF. Maybe adding another molecule between the main molecule and quartz surface could be a solution. This is mostly a chemical problem that can be solved by chemist (the writer is a physicist).