Bulk disc resonators for heavy metal detection in drinking water

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Introduction

High concentration of heavy metals in drinking water can cause many diseases in the population. Due to the lack of big rivers, Denmark is highly interested in new cheap ways of continuous monitoring the quality of the drinking water in the ground

Description of device

A bulk disc resonator is a microfabricated silicon based device, which consists of a polysilicon disc surrounded by the input electrode and the output electrode (see Figure 1) - In this case, with a diameter of 60µm. The disc is actuated electrostatically - vibrates at its resonance frequency, f_0~66MHz. Since f_0 depends on the amount of added mass on the surface, it is possible to see a shift down in resonance frequency if a mass is deposited on the disc. It is this phenomenon that is used in this project to detect heavy metals on the surface of the resonator.

Actuation and readout

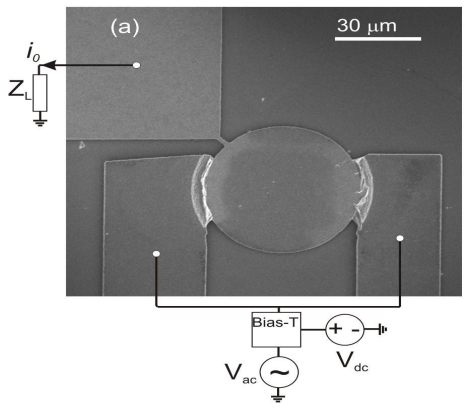
Actuation and readout of the disc works with a electrostatically actuation and capacitive read-out. In figure1 the device is seen. Here an AC and DC potential are placed between the disc and the capacitor plates. When the AC frequency hits the resonance frequency of the disc the vibration amplitude of the disc will increase, and thereby increase the change in capacitance between the plates and the disc. This will lead to a higher current flowing and thereby be seen as a signal peak. A measurement - to sweep through a range of AC frequencies while monitoring the current. From this the resonance frequency can be precisely measured.

Chemistry

If a specific heavy metal is to be detected, a selective functionalisation layer is needed on the surface of the disc. In this project thiol chemistry is used. The sulfur atom will attach to the gold layer deposited on top of the silicon surface while the other end is functionalised to react with Cu. When the Cu attaches the surface should be possible to measure the added mass as a resonance frequency shift, df_0, of the disc.

Results

Next the thiols are attached to the devices. In this project two types are used. This means that three chips were made. One with CGGH, one with Cys and one blank control chip.
Below on Figure2, results are seen from the CGGS, Cys and blank chip. It is seen that CGGH-chip and Cys-chip resonance frequency drops as expected while the resonance frequency of the blank stays constant.



lustration 1:Figure1: Picture of the device. Both the disc and the capacitor electrode are seen.

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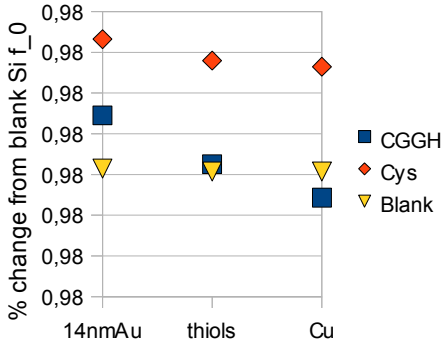

Figure2.
Plot of chips with two different thiols and one blank.