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CS35L Lab 2

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Assignment 10 Report: Scientists Develop Tooth-Mounted Sensors That Can Track What You Eat

Raymond Lin:

Scientists have developed a new technique in monitoring dietary intake. Previous methods of dietary monitoring has had numerous limitations. Some were as bulky as mouthguards, while others required constant replacement of a particular part of the sensor. However, this new development entails none of the above traits. It is a small sensor that is adhered to the surface of the tooth.

The sensors monitors the dietary intake of a particular individual by analyzing the physiological properties and chemical compounds of the eaten foods. Physiological properties differentiate certain foods from others. These properties include pH level, temperature, salinity, alcohol content and glucose content. These properties influence the electrical properties of the sensor and results in a change in the frequency or amplitude of the wave that is sent out by the device. The device acts like a “tiny antenna, collecting and transmitting waves in the radiofrequency spectrum [1]”.

The structure of the sensor is split into three layers: two gold metal plates on the top and bottom and a bioresponsive interlayer. The two gold metal plates are actually broadside-coupled split-ring resonators. The “geometrical parameters of this structure [split-ring resonator] determine its resonance frequency [2]” that is emitted in response to a particular stimuli, in this case, food. While there are two designs to the split-ring resonator, the edge-coupled split-ring resonator and the broadside-coupled split-ring resonator, scientists chose the broadside-coupled split-ring resonators. They “are favorable because of their combined small form factor and lower resonant frequency that make the devices practical for use with traditional RF instrumentation [3]”. Additionally, the side-by-side orientation of the two resonators produce a localized electric field between them, “limiting the influence of the external environment on the device response [3]”. The split-ring resonators are also covered by a thin film of silk filron, the same material as the interlayer. This allows the biomolecules of the food to permeate into the interlayer. In short, the split-ring resonators are the instruments in the sensor that sends out radiofrequency waves.

The bioresponsive layer is composed of a silk film and a silk hydrogel which work in conjunction to alter the resulting radiofrequency wave. It is able to record varying degrees of ionic strength, glucose concentration, and solvent concentration. Furthermore, the interlayer thickness influenced the frequency and quality of the emitted wave. Because a thicker interlayer produced a higher frequency and were less sensitive, scientists chose to go with a thin interlayer, for its low frequency, which, as mentioned previously, works better with RF instrumentation. In short, the bioresponsive interlayer swells and absorbs the surrounding solvent and changes the resonators’ frequencies accordingly.

Kenneth Le:

Now there are two components to the biointerlayer that allows the measurement of the physiological characteristics that help classify and define the food that the sensor interacts with. A silk film as well as a silk hydrogel that are both in their own respect are sensitive to their own specific physiological traits.The silk film component of the interlayer is sensitive to the aspects of glucose concentration(sugar content), ionic strength (salinity content), and solvent concentration. What we notice is that when recording these measurements not only is the frequency of the resonator affected by these traits but also the amplitude of the waveform which gives us another dimension to which we can differentiate different foods who may in combination with other foods may produce the same frequency change but not the same waveform. The silk hydrogel component of the biointerlayer is more responsible for measuring the temperature and pH level of the biomolecules penetrating to the interlayer as the hydrogel expands and reacts to changes in temperature from thermal expansion within the resonator and changes in charge with the interlayer. These both can dramatically affect the frequency as in a dielectric constant the frequency is dependent on the movement of masses encased within. The integration of both of these compounds allow the sensor to comfortably differentiate distinct liquids from one another such as soup, saliva, apple juice, mouthwash, and tap water by observing the frequency and amplitude of the waveform given off by the resonator.

The development of this technology gives greater potential for radiofrequency technology to be used in more user based applications as the ability to autonomously gather data like the foods that you’ve eaten throughout the day through a more advanced and refined design of this sensor would allow individuals to monitor aspects of their personal health in new ways. For instance, the use of the food sensor could provide data to track your diet automatically or in future designs of this technology be able to monitor your heart rate, temperature, or other variables that could give preliminary signs to emergency medical illness(,fevers,dehydration,stroke etc.). Not to mention this technology could allow for the potential of large data collection projects in which data received from these sensors are uploaded to a cloud database that could be referenced back to with direct timestamps to observe medical patterns. Most of the resources are available to us except the technology needs to be much more refined to make it viable for users to effectively and efficiently use in the future.

Works Cited

[1] “Scientists Develop Tiny Tooth-Mounted Sensors That Can Track What You Eat.” *Tufts Now*, ACM TechNews, 22 Mar. 2018

[2] Alici, Kamil B, and Ekmel Ozbay. “Electrically Small Split Ring Resonator Antennas: Journal of Applied Physics: Vol 101, No 8.” *AIP Publishing*, American Institute of Physics, Feb. 2007

[3] Tseng, Peter, et al. “Functional, RF‐Trilayer Sensors for Tooth‐Mounted, Wireless Monitoring of the Oral Cavity and Food Consumption.” *Freshwater Biology*, Wiley/Blackwell (10.1111), 23 Mar. 2018