A Wireless Sensor for Monitoring Encapsulation Performance in Non-hermetic Implants

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1. Introduction

For years, medical devices have relied on the titanium housing to protect the inside electronics. Such devices, however, end up to be bulky and result in low specificity when stimulating neurons. Miniaturization is essential to target more specific populations of neurons in order to develop precise bioelectronic medicines [1]. Polymer encapsulation is a type of non-hermetic encapsulation, which could greatly reduce packaging size while protecting the electronic circuitry. One main drawback, however, would be the loss of hermeticity and a method to predict lifetime reliability [2]. The lifetime reliability of such a package depends on the adhesion quality between the polymer and the substrate. Since all polymers are permeable to water moisture, water could condense at the polymer-substrate interface jeopardizing the adhesion quality. Such a phenomenon would eventually lead to corrosion and device failure by exposing the electronics to liquid water. In this work, we aim to detect the problem at its early stage: when water condenses at the interface. Fig.1 shows a system-level view of the proposed wireless sensor. When the sensor detects liquid water, a signal will be transmitted well before any corrosion has taken place.

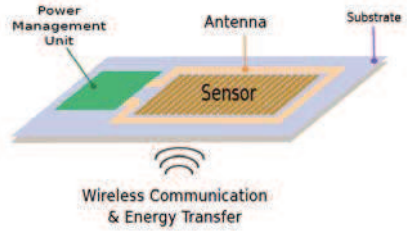
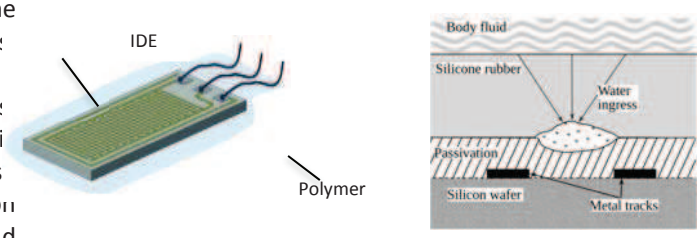


Figure 1: Wireless sensor for monitoring adhesion quality in-vivo.

2. Methods

So far, inter-digitated electrodes (IDE) have been used during long term soak tests to monitor and assess the substrate-to-encapsulant adhesion quality [3]. Fig.2(a) shows an IDE structure in which the adhesion quality is monitored by measuring the impedance between the comb structure. Such a method, however, shows adhesion failure in its final stages, when water condensation has accumulated, created a larger gap in the interface and led to leakage (Fig. 2b). The method proposed in this work is to use a sensitive micro-sensor that could detect liquid water forming at the interface and signaling the onset of failure well before any corrosion has taken place.



(a) (b)

Figure 2: (a) a polymer encapsulated IDE for monitoring adhesion quality, (b) water condensation at interface[2].

3. Discussion

Such a monitoring sensor could significantly shorten the duration of soak tests. Moreover, it could be used as a reliability sensor for future non-hermetic implants. Nevertheless, there are some technological challenges in the design and fabrication of such a unit. One main challenge is to design the sensor in a way that it could detect liquid water at the interface well before it has reached the electronics underneath. Another challenge would be to design and place the sensor on the implant in a way that it would detect condensation well before any condensation or corrosion takes place on other locations on the implant.

4. Conclusion

Polymer encapsulation as a packaging solution is a viable candidate for miniaturizing future implants. For such packages, however, no hermiticity check could be performed to predict lifetime reliability. In this work, we have brought forward the idea of using a surface monitoring sensor to detect water condensation at its very early stages. Such a sensor could ultimately be used in situ as a diagnostic self-check for future non-hermetic implants.

References

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