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Simplified Glass Encapsulation of Medical Devices

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Background

When water vapour in the environment or liquid water from body fluids enters an implantable package, it will damage any electronics present. There are a number of routes of entry for water; through the package walls, seals, and feedthroughs.

We set out to find a simple way to hermetically seal implantable electronics, while not using titanium or alumina, as it is expensive to build.

By using glass in conjunction with an appropriate sealant we can create a long lasting sealed enclosure. This is because glass is very impermeable to water vapour or water passing through it. Plastics can also be used instead of glass, depending on the intended application. An example is polyether ether ketone (PEEK).

Cyanoacrylates, epoxies, and silicones are examples of different sealants.

Desiccants, such as silica gel, can also be used inside the package to take up moisture that accumulates, to extend the life of the package further.

Poly(p-xylylene) polymers such as Parylene can also be used as a sealing material.

Aims

- To determine whether glass in combination with a sealant can create a long lasting implantable package.
- To accurately model implantable package lifetimes with different materials and physical parameters.
- To model the impact of desiccants on packages lifetimes.

Method

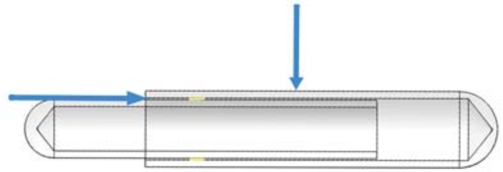
MODELING

Using the specific parameters of the target package (enclosure and seal materials, enclosure and seal sizes, amount of desiccant) with the model produces a time to reach 63.2% RH (relative humidity). We used models described by previous work in the field.

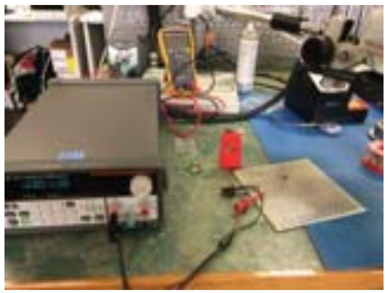
TESTING

With two half cylinders of glass we filled the gap in between them to create a seal, with a specific length, and tested the longevity of each sealant. The length of the sealant seal was varied according to the time avaliable to test the enclosures. This is then equated with the model to see if it predicts the correct time period to 63.2% RH. The humidity levels were monitored in two ways: humidity test strips (paper that is saturated with cobalt chloride) that change colour in different humidity levels; and wireless humidity sensing electronics. These enclosures were placed in a water bath at 37 °C, with the humidity checked at regular intervals to determine the time to reach 63.2% RH.

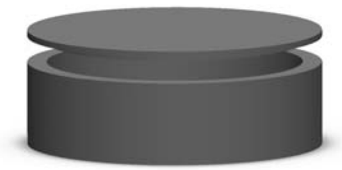
Sample glass capsule.



Cross section of glass capsule. Blue lines indicate routes of moisture entry. Yellow lines show the sealant.



Humidity sensing circuit testing.



Concept of PEEK Capsule.

Summary

MODELING

Packages made of; glass and polydimethylsiloxane (PDMS) were predicted to last a shorter period of time compared to packages made of glass and epoxy. Packages of glass and Parylene C (specific Parylene variant) were modeled to last a longer period of time than glass and PDMS, but not glass and epoxy packages. When desiccant is added all packages increase their lifetimes. This also increases the Parylene package past epoxy.

Enclosure Type (1 cm³ internal volume)	Glass & PDMS	Glass & Epoxy	Glass & Parylene C
Time to 63.2% RH w/o Desiccant	2.13 days	1.28 months	3.76 weeks
Time to 63.2% RH w/ Desiccant	1.39 months	7.68 months	3.43 years

Table of results. All sealant lines of different lengths for practical reasons. PDMS 1.1cm, epoxy 0.08cm, Parylene C 20 µm.

TESTING

In progress.

References

Dahan, N. (2013). The Application of PEEK to the Packaging of Implantable Electronic Devices, (Doctoral dissertation, UCL (University College London)).