Print ISSN : 0022-2755
Journal of Mines, Metals and Fuels
Contents available at: www.informaticsjournals.com/index.php/jmmf

Development of Biodegradable Pressure Sensor for Orthopedic Applications

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Abstract

Many injuries & fractures are corrected by the means of surgery and regularly monitored by regular scans such as MRI, X-Ray etc. As the technology has improved over the years there are many advanced methods such as biodegradable pressure sensors which can be implanted during the surgery and used for extracting useful data. The material used to build this pressure sensor will be completely made of biodegradable materials to cause no side effects or harm to the body. The preferred fabrication method is Ink jet printer method or Screen-printing method. This biodegradable pressure sensor will be a huge boon to all humanity as it will be able to provide live data of pressure and strain acting on the injured bone which will be useful in recovery and rehabilitation. With this data the doctor can access the recovery and tailer the activities of the injured bone.

Keywords : *Biodegradable pressure sensor; inkjet; screen printing;strain;rehabilitation.*

1.0 Introduction

Globally, 178 million new fractures occur each year due to road accidents, direct blow, sports injuries etc. which accounts to the rise of 33.4% of fractures when compared to the year 1990. Among these 82% of the fractures caused due to accidents are prescribed to undergo surgery.

The objective of surgery and rehabilitation is to restore the tissues to their pre-function, with biomechanical properties as close as possible to native properties.

The fractures which are corrected with aid of surgery need to be tested using MRI or X-ray scan on regular basis to monitor the recovery of the patient. Prolonged use of such means would not be feasible for a common man and on the other hand it may also lead to many minute unnoticed health problems due to the harmful rays used during the process.

As the technology has developed rapidly over the years there are many alternative advanced recovery monitoring devices developed in the recent past. A diagnostic tool that measures the biomechanical properties of the repair site in real time would represent a significant step towards improved assessment of the healing and development of personalized rehabilitation strategies.

These sensors will be implanted during the surgery and used for extracting useful data. The material used for the sensor will be biocompatible. Biodegradable sensors could give continuous information about the tissue strain during the rehabilitation process, as well as during the patient's daily activities.

The present research work is carried out to study the variation of resistance of the circuit with the load/pressure applied.

2.0 Material and Method

2.1 Material used to make the sensor

The biodegradable pressure comprises of two key components:

1. Base plate
2. Sensor circuit

Here the base plate is made of PLA (polylactic acid) which is biodegradable and depict good results when subjected to tensile and flexural stress.

The material selected for the fabrication of the biodegradable pressure sensor circuit is nano conducting lab grade silver paste having 99.9% purity, concentration 80-85%, APS of 10-20nm.

2.2 Design details

The biodegradable pressure sensor design has been taken for 4cm × 4.6cm scale with 4 electrodes. More the no. of electrodes better the conductivity and resistance variation when under load.

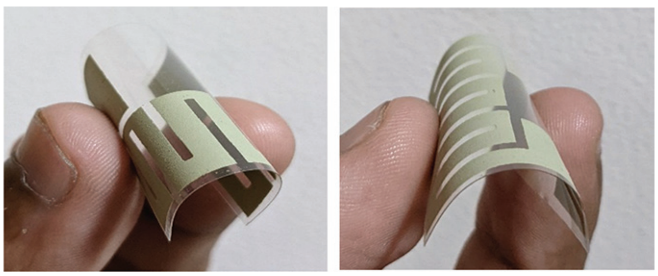

Figure 1

2.3 Fabrication of the sensor

Screen printing process is chosen as the fabrication method for the development of biodegradable pressure sensor as it is of low cost and easily available method.

Screen printing involves 5 major steps:

1. Design creation
2. Preparing the screen
3. Exposing the emulsion
4. Creation of the stencil
5. Printing

Design creation: The design is either drawn or printed on a transparent acetate film. In this case the design is prepared on Catia V5 according to the calculations and the drawing is printed on a transparent acetate film which will be used to create the screen.

Preparing the screen: The screens are made up of silk or nylon or polyester mesh emulsion liquids undergo reaction when exposed to UV light which allows it to harden. The emulsion liquid is applied on both sides of the mesh equally using a sneeze and this must be done at low light or dark room.

Creation of the stencil: The drawing sheet must be placed over the mesh on one side and a glass pane must be placed on it to ensure if the transparency is flat against the screen. This is then exposed to bright sun light or UV light. The exposed area is hardened, and unexposed area is washed away using water as it is soft.

Printing: A thick layer of silver ink is placed on the mesh and at the right position. Using squeeze the ink is applied on the PLA sheet by applying force moving it back and forth.

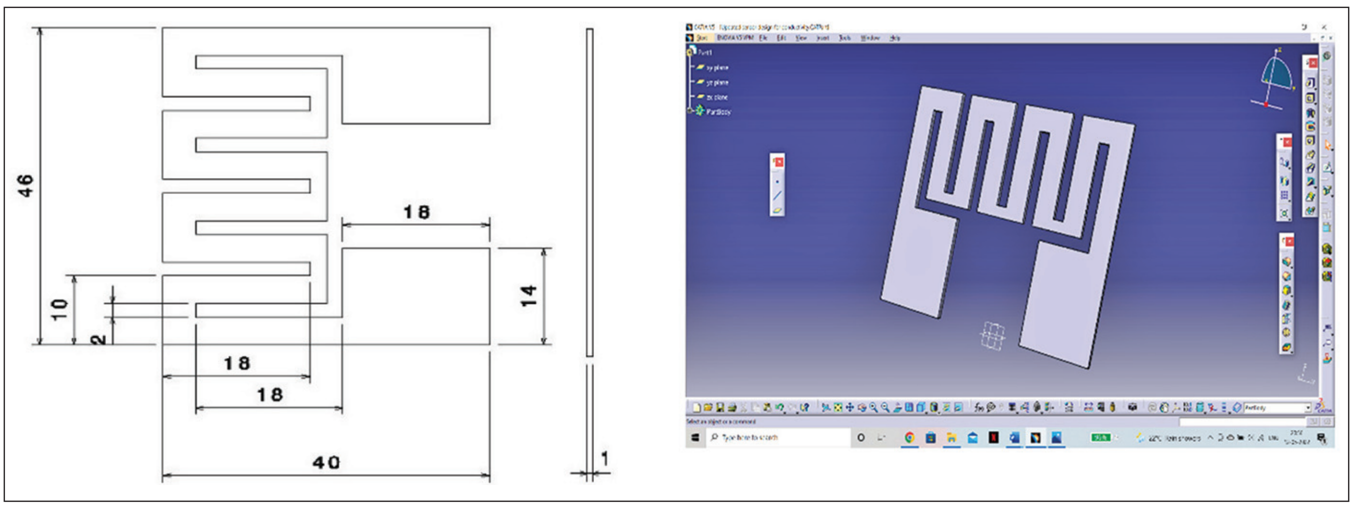

Figure 2

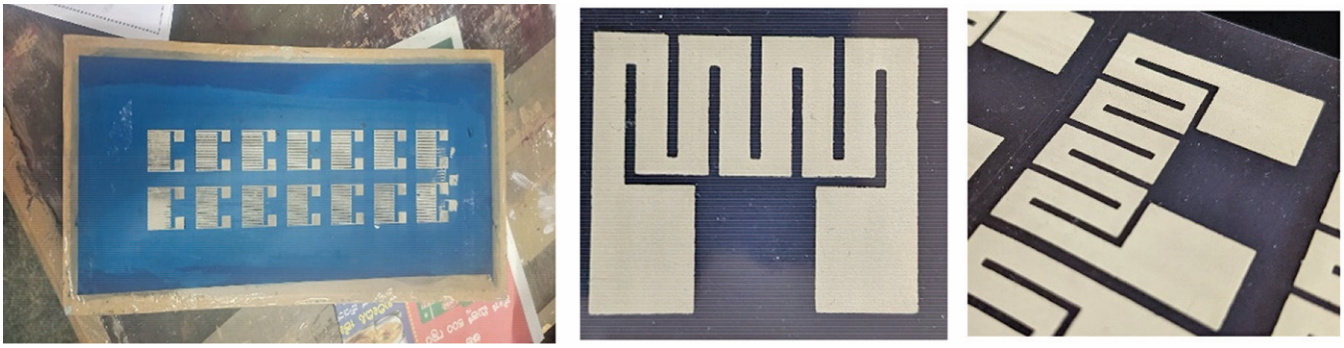

Figure 3

3.0 Results and Discussions

3.1 Conductivity test

As the sensor was printed with a pressure sensitive conductive silver paste the conductivity test depicted good result. As the load cell test was conducted by applying pressure gradually there was noticeable change in the resistance values until 1.4 MPa after which the sensor reached a saturation point with further increase in pressure.

3.2 Degradability test

The degradibility test is conducted in the univeristy laboratory in order to understand the rate of degradation with respective time and temperature. The chemical reagents used for the degradibilty test are:

4. Hydrogen peroxide solution
5. Buffer solution
6. Fenton reagent

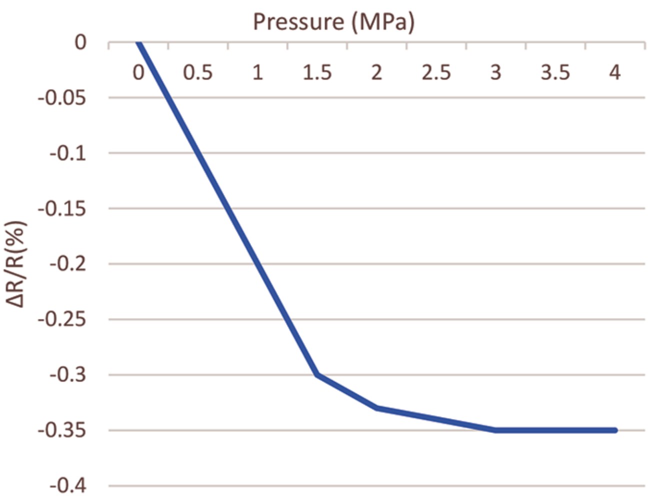

Figure 4: Relative change of resistance vs applied pressure

Here the six samples of the sensor are placed in 6 different beakers having 3 types of reagents in which each type of solution will have 2 sensors each.

Before placing the sensors in the solution, the weight of the sensor is measured using density measuring instrument and then the PH values of the solutions are measured after immersing the sensors into the solution. After which the beakers containing the samples will be placed in an oven to maintain a constant temperature of 37ºC to replicate the body temperature. This data will be used to compare the results after 7 days.

Table 1

Sample	Weight before testing (w1)	Ph before testing (Ph1)
A	0.6199g	7.04
B	0.6075g	7.10
C	0.6228g	6.53
D	0.6301g	6.59
E	0.6285g	1.19
F	0.6160g	1.25

Figure 5: Samples for degradability test

3.3 Microstructure

The microstructure of the sensor sample was observed under the Optical Metallurgical Microscope to observe and analyse the bonding between the silver particles and the base material PLA.

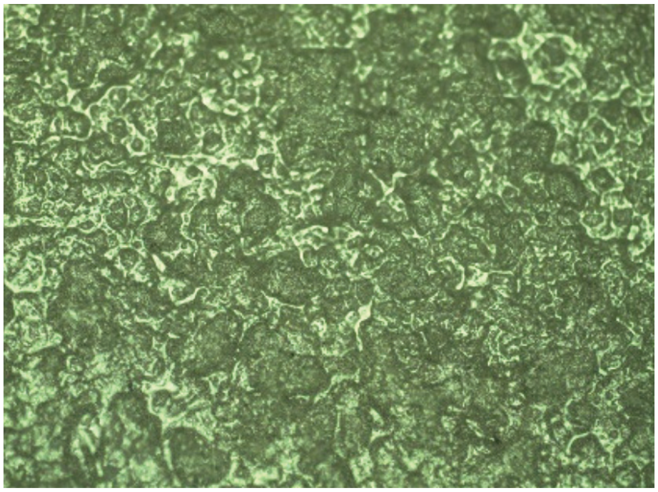

Figure 6: Microstructure of the sensor

4.0 Conclusions

The biodegradable pressure sensor made of silver and PLA material is safe and degradable sensor which can be implanted into the body with further development. This sensor will help in transmitting the accurate readings of strain and pressure acting on the injured bone with which the doctor can tailor the day-to-day activities and help in faster recovery. This affordable biodegradable sensor will be a huge boon and major development towards the medical department.

Acknowledgements

The authors thankfully acknowledge the facultyof REVA University, Bangalore and Chikpet screen printing center, Bangalore for the support rendered in carrying out this research work.

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