DEVELOPMENT OF A SENSOR FOR DYNAMIC PROSTHETISTS/ ORTHOTISTS USING AN INTELLIGENT IPMC PRODUCED BY PLASMA

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Abstract. *The study of the structure and properties of membrane ion perfluoranato (also known as Nafion) have been performed with great intensity since the beginning of the century due to its potential for retention and performance of ion exchange. The IPMC is a composite consisting of an ionic polymer-coated metal, widely used as a micro actuator/sensor for biomedical applications, mechanical and robotics, among others. The construction process of the IPMC is time consuming, requiring the completion of several steps. The initial cleaning of the polymer, made to remove the superficial layer of fat that forms on the polymer, also serves as erosive agent. The ion erosion by oxygen plasma promotes the modification of surface functional groups, increasing the contact surface of the IPMC for the deposition of silver (Ag). The use of plasma during the process tends to reduce the construction time of the IPMC, its cost analysis of the thickness of deposited silver will be realized through images obtained by optical microscopy (OM) and scanning electron microscopy (SEM). Later these images will be worked on specific programs.*

Keywords*: IPMC; Plasma; SEM.*

1. INTRODUCTION

The loss or destruction of a member of extreme functionality leads to reduction in the activities undertaken by the individual and major change in their appearance (SCHULZ et al. 2001; Carozza et al. 2004; SCHULZ et al., 2005), also causing problems psychological (MASSA et al. 2002; J. Pillet and A. DIDIER, 2001).

The WHO estimates that about 10% of the population of any country in peacetime has a disability, and 2% is physical disability.

The use of prostheses and orthoses for members is before 200 BC (Carvalho et al., 2000). Dentures are used to replace a member, or not performing its function, since the bracing perform only the function of the organ, but no substitute. For use in limbs, dentures replace any member, while the braces are attached to the member user to recover the function, the motion lost. One major goal in the development of prosthetics and orthotics is the restoration of the functionality of a member, to recover the amplitudes and movements required in the performance of the main daily activities.

This requires that prosthetists / orthotists have a multitude of sensors and systems to enhance the feedback to the control system and the user. Such as the human hand, a sensor network should be built around the mechanism to transmit information. Several sensors have been used for this purpose: hall effect sensors (Pons et al. 2004; MASS et al., 2002), three-dimensional force sensor (Carozza et al., 2003), current sensors, shunt (ROCHA, 2007), among others. However, these sensors have not been able to cover the entire length of the prosthesis and not to provide full feedback to the user.

In search of effective results, more studies are being conducted in search of new materials that adapt and respond to existing needs in the development of sensors for this aplicação.Among existing research, electroactive polymers have been widely used in the detection of prosthesis because of its flexibility and response to angular displacement (Biddiss and CHAU, 2006).

The electroactive polymers (PE), known as EAP, are a new class of smart materials that have many characteristics that make them interesting for application in developing a new class of prosthetics and orthotics.

EAPs are materials with high potential as actuators or microactuators and construction can be divided into two main groups (HACKL et al, 2005).: Electronic EAPs and ionic EAPs (BAR-COHEN, 2004).

Today there are already studies that utlize ionic EAPs as a basis for the construction of sensors that can develop the necessary functions as a mechanism for the baud in for prosthetists / orthotists. These sensors are built from an IPMC consisting of two metal electrodes, one on each side, and a core perfluoranato ion exchange membrane.

The need for construction of prostheses / orthotics and more similar to the User adptadas shows the need to develop mechanism to mimic these handling characteristics and then determine and develop a system that can generate information for precise control and similar to the member replaced, which is the objective of the study.

2. EXPERIMENTAL PROCEDURE

An IPMC (Ionomeric Polymer Metal Composite) is a type of electroactive polymer, formed by two metal electrodes and a core polymer, Nafion ® (DuPont), FLEMION ® (ACG - Asahi Glass) or ACIPLEX ® (Asahi Chemical Industry).

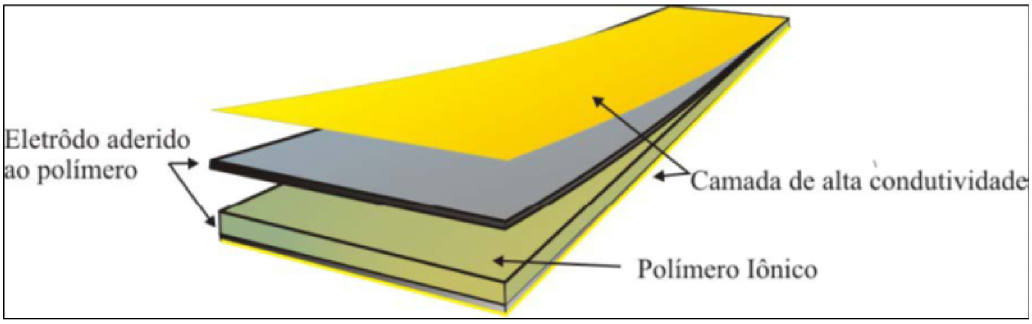

Figure 1. IPMC, a graphical representation of your layers. (Adaptador.D.Griffiths (2008).

It was developed with a core of IPMC and Nafion ® electrodes of silver (Ag) of approximately 18.0 x 2.0 cm. For each coating was applied to prevent losses by evaporation of the properties and increase the conductance of the electrodes.

2.1 Development of an IPMC

2.1.1 Assembly Process

The assembly process of the IPMC is described in different works, but the most complete and accurate descriptions, which were followed for its assembly, can be found at Pak et al. (2001) and Kim and Shahinpoor (2003). This task is accomplished differently step deposition of the metal electrode. This step is performed by plasma. The process of assembling an IPMC plasma is described below.

The construction process is divided into three main steps: surface treatment (cleaning), Sputtering Deposition of Silver for Hollow Cathode.

Surface Treatment

This step is responsible for preparing the polymer matrix to receive the metal electrode. Held cleaning the Nafion ® film, removing all impurities. After that, the material should be ready for the metal ions.

For this, the sequence of steps must be performed:

- Sanding the Nafion ® film, removing all the coverage that may be in the material.
- Place the polymer in an ultrasonic bath with deionized water for a minimum of 30 minutes, until they drop all visible impurities.
- Boil the polymer solution in 2 N HCl for 30 minutes.
- Clean the polymer with deionized water.

Deposition of Metal-ion

Esta etapa é responsável por realizar a adesão do íon Ag ao filme de NAFION®, dispersando-o por toda a superfície do polímero.

Equipment hollow cathode deposition

To perform the deposition of silver film on the polymer used was a reactor for plasma deposition of films. The reactor has been developed entirely within the DFTE / LabPasma.

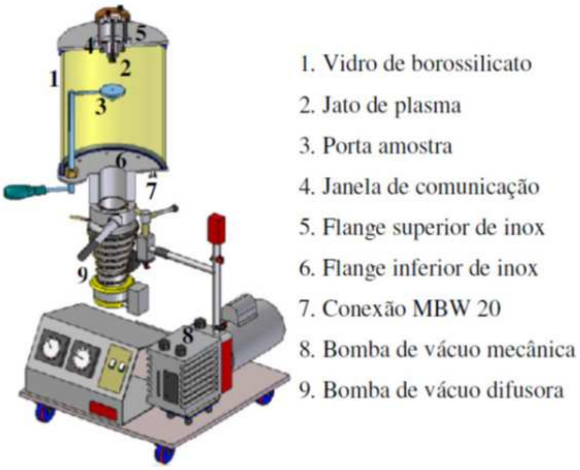

Figure 2. Reactor plasma deposition of films used in this study (Almeida, 2008).

Figure 2 shows a perspective vertical section of the deposition chamber, indicating the positioning of key components. The sensor is positioned in the high vacuum chamber bottom flange. The sample has a door system that allows the radial displacement at different distances from the cathode. The different distances except substrate were set previously, ranging from 10 to 50 mm, with the front door to the target sample.

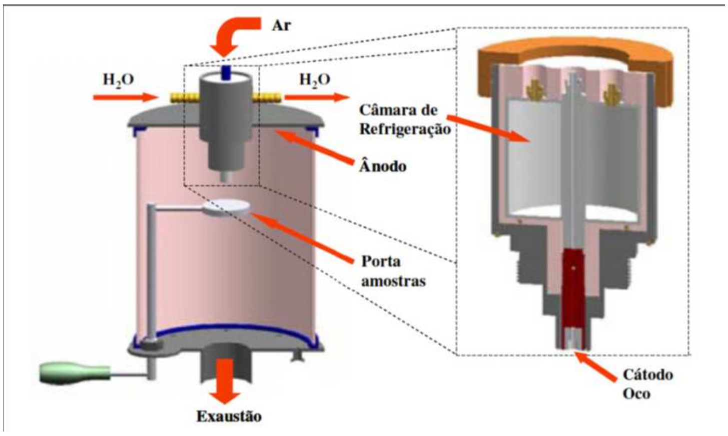

Figure 3. Cross section of the deposition reactor, showing the layout of its main components. Highlight: cutaway view of the arrangement of the hollow cathode (Araújo, 2006).

The target is a cylinder of Ag, with nominal purity of 99.99%. It has 10 mm outside diameter, with a cavity 5 mm in diameter and 5 mm deep. The cathode also has a shield to prevent the formation of plasma in the outer wall.

The specimen holder made of stainless steel was attached to a feedtrough, to allow their radial displacement without loss of vacuum and to avoid any contamination of the substrate during the initial phase of pre-sputtering of the cathode.

Thus, the samples were removed from the plasma beam, and placed the head on even when the actual start of the deposition.

Construction of Cathode Silver

For the construction of the silver cathode, broke from a base of stainless steel AISI 316, as shown in Figure 3.3, where the silver powder, certified purity of 99.99%, acquired in trade has been pressed.

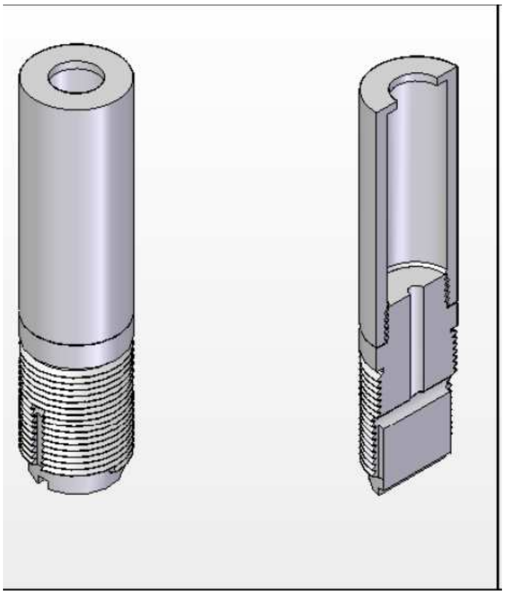

Figure 4. Schematic drawing of the array where the powder was compacted silver.

The pressure of compaction of silver powder was 20 MPa in a conventional vertical press. After compaction of the material, the cathode was sintered at a temperature of 1000 ° C and then a 2.5 mm central hole, was made the cathode.

Deposition of silver film on the EPAs

Samples with 18 cm length of the polymer (Nafion ® 117) were placed in a holder above the specimen holder at a distance of 7 cm from the plasma jet. This distance has been determined from studies, for smaller distances caused a large amount of heat the samples so that they suffer burns. Longer distances did not result in more warming effect, but the deposition of the film was very irregular.

2.2 Characterization of the samples after the deposition

To evaluate the effect of plasma treatment Seram used the following methods of characterization:

- MO to assess whether there was deposition of silver film on the surface and its regularity.
- SEM (SEM) to analyze the shape, size of silver particles deposited on the sample surface and the thickness of the film formed.
- X-Ray Diffraction, to verify the phases of the film.

3. RESULTS AND DISCUSSION

The final results on the assembly of IPMC have not yet been obtained.

The step surface treatment was successful, and its objectives achieved. Impurities present on the surface of the polymer were withdrawest, and roughness were promoted to increase the contact surface of the polymer facilitates the adhesion of the mine on their surface.

During the course of the film deposition step of silver were found some difficulties in relation to the support bracket of the polymer samples and for the parameters of reactor operation.

The support has overheated in the course of the process and the best operating conditions have not yet been found, which ended up causing burns in the samples. In order to solve this problem, a new type of support is being tested as well as the operating conditions so that we can optimize the process.

When these problems are solved, we can then take the step of deposition of the silver film.

After deposition, the surfaces of the samples will be analyzed through optical and electron microscopy to analyze the deposited film (its thickness and regularity) and through the technique of examining EDS phases of the deposited film.

4. CONCLUSION

In order to develop methodologies and mechanisms to contribute to the improvement of functional prosthetic limbs was presented in this paper the possibility of obtaining a sensor that meets the current needs of prostheses / orthoses as stimuli and responses, through an act that IPMC as a force and displacement sensor with low power consumption.

Although it has not yet been possible to carry out the complete assembly of an IPMC plasma due to the problems already cited in this study, it is believed that this technique can generate the expected results, which ensures the continuation of this work and we are sure of a presentation of future work presenting the results and appropriate conclusions about the same.

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7. RESPONSIBILITY NOTICE

The authors E. G. Lopes, C. A. Júnior, C. L. B. G. Neto, and D. A. P. Nagem are the only responsible for the printed material included in this paper.