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Nanotachnology:structural study of a micromembrane compound by polymer and materials magnetic

Mohamed BELKACEM[a], Samir BENDIB[b]

[a] *Département of Electrical Engineering, Batna university*
[b] *Département of Electrical Engineering, Batna university*

Abstract

From day in day one can see the evolution of technology and more particularly that of Nano. In this context, the nanosciences are a study of the phenomen and the handling of the matter on the scales atomic, molecular and macromolecular, where the properties differ appreciably from those which prevail with more large scales. The nanotechnologies, as for them, relate to the design, the characterization, the production and application of structures, devices and systems by the control of the form and the size on a nanometric scale.
Indeed, they use, while allowing new possibilities, disciplines such as optics, biology, mechanics, chemistry, or microtechnology progress of the nanotechnologies and the nanosciences,
In this paper we present the amelioration brought by polymer(PDMS) and Permalloy use in nanosystem and in electromagnetic microactuator devoted for the microfluid applications that need moving infime quantity of fluid such as the micropumps and microvalves especially in the biological domain .we present the resultats of stimulating our microactuator in different geometrical shapes.

Keywords: nanotechnologie,microflui d,PDMS,nanomateriaux,labonchip,nanobiologie,micropump,microvalves;

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1. Introduction

The increasing interest in point-of-care devices and lab-on-chips to reduce cost of diagnosis and increase the well being of patients calls for low cost, high throughput manufacturing technologies to realise the commercialisation of such systems. For this reason, the use of polymers and thermoplasts to produce micro systems for diagnostic purposes has increased due to their attractive features such as low material cost, diversity in chemical and physical functionality and their diverse processability [1].
General hurdles to overcome are bonding of different materials onto each other, maintaining for example biological and fluidic functionality during the bonding process and adjusting microscale elements onto each other with high precision [2].

2. Description of microactuator, similitude laws and scale reduction

When a ferromagnetic object comes in a magnetic field, the coil attracts the object. If we add to the system, a permanent magnet that attracts the object in the opposite direction, the forces of attraction and repulsion are obtained by a direction change in the external magnetic field [3].The studies of similitude laws and scale reduction have shown the efficiency of the magnetic MEMS.

The proposed structure constitues the encrusted membrane in a bloc as figure 1 shows :

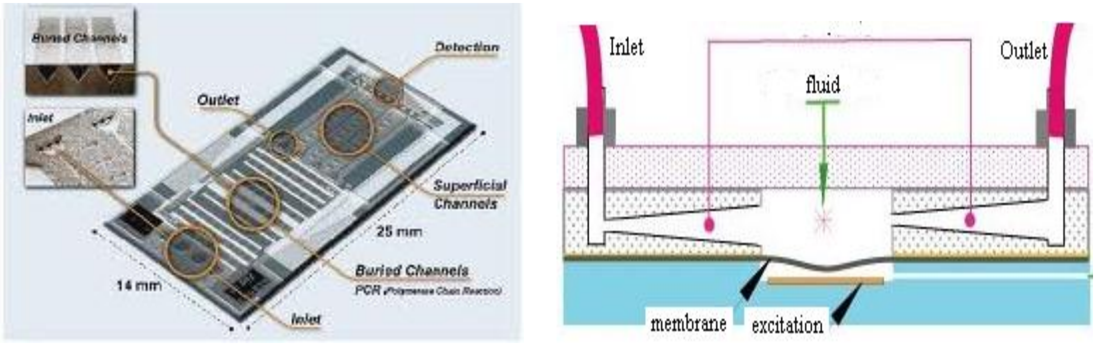


Fig. 1. (a)Labochip, (b) micropump

The functioning of this pump is based on the coupling between an actuator, a membrane and the countained fluid in the cavity. The membrane loses its shape and varies the cavity volume [4].

4. Why polymers ?

The concept of microsystems based on Silicium is sometimes limited by certain intrinsic properties to Silicium , as its rigidity, and being fragile to choc in the structures of suspension and its thermic conductivity……etc.The use of polymeres in microsystems give a solution for certain problems. Some advantages include their cheap cost and their facility ir easiness when used in characteristic dimensions that go from the centimetre until the micron , to see beyond this in certain cases. Among these polymers, the polydimethylsiloxane(PDMS) constitutes the elastomer largely used in microfluidic microsystems due to various factors; The low cost of the material itself, its non-toxicity, its optic transparency in the visible and ultra-violet, its gas permeation, its being deformed (E=360kPa-9MPa), it is also easy to process in a white room.[5]

3. Analytic study of a circular membrane

Our membrane can be simplified as shows as figure2 :

The relation arrow-pression in the general case of an encrusted circular membrane is given by the relation (1) [6]

$$P=\frac{8}{3}\frac{E}{1-\nu}\frac{e^3h_0}{a^4}\left[\frac{2}{1+\nu}+C_k\left(\frac{h_0}{e}\right)^2\right]+4\frac{\sigma_0 e h_0}{a^2} \qquad (1)$$

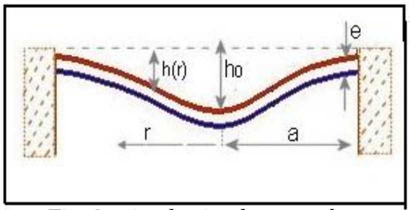


Fig. 2. simple circular memebrane

From the equation (1), we deduce the arrow expression of the pression functioning :

$$h_0 = 2\sqrt{\frac{1}{3C_k}\left[2\frac{e^2}{1+\nu}+\frac{3}{2}\frac{1-\nu}{E}a^2\sigma_0\right]}.\sinh\alpha \qquad (2)$$

$$\alpha = \left[\frac{1}{3}\operatorname{arc\,sinh}\left[\frac{\frac{3}{8}\frac{1-\nu}{E}\frac{a^4}{e}\frac{P}{C_k}}{2\sqrt{\frac{1}{3C_k}\left[2\frac{e^2}{1+\nu}+\frac{3}{2}\frac{1-\nu}{E}a^2\sigma_0\right]^3}}\right]\right] \tag{3}$$

Nomenclature

P	applied pressure on the membrane
ν	Poisson coefficient
e	membrane thickness
h_0	central moving arrow
a	membrane ray
σ_0	initial constraints(stress)
E	Young module
Ck	correction coefficient

5. Analytic and numerical results of simple circular membrane

The complexity of geometry and phenomen require the use of the programming outils, this is why, we have used a code of calculating based on the finite elements methods which is ANSYS®..The table1 gives the characteristics the used materials [7]:

Table 1 : Caracteristics of the used materials [5]

	Young modules [GPa]	*Poisson Coefficient*	*Masse volumique [Kg/m^3]*
PDMS	0.009	0.48	1410
Permalloy	94.6	0.3	8200

The obtained results in case of simulation of a PDMS membrane are presented in figure 3, where we notice a similar behavior theoretical curves and those of simulation :

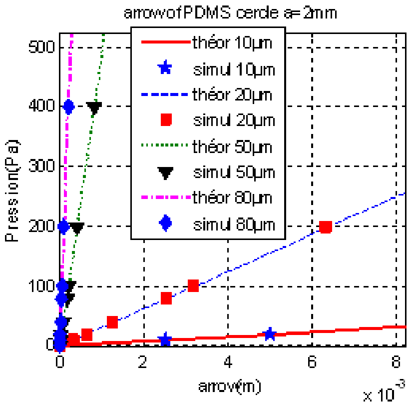


Fig. 3 Théoretical and simulation results for a circular membrane for a ray : a=2mm and different thicknesses : e=10 ; 20 ; 50 ; 80 µm

6. Numerical modelisation of a membrane in PDMS bloc

Our microactuator is shows in figure 4

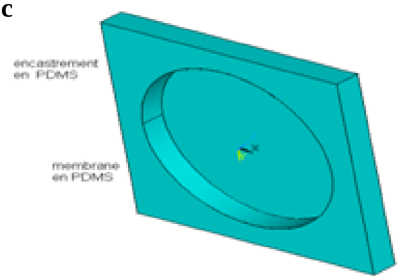
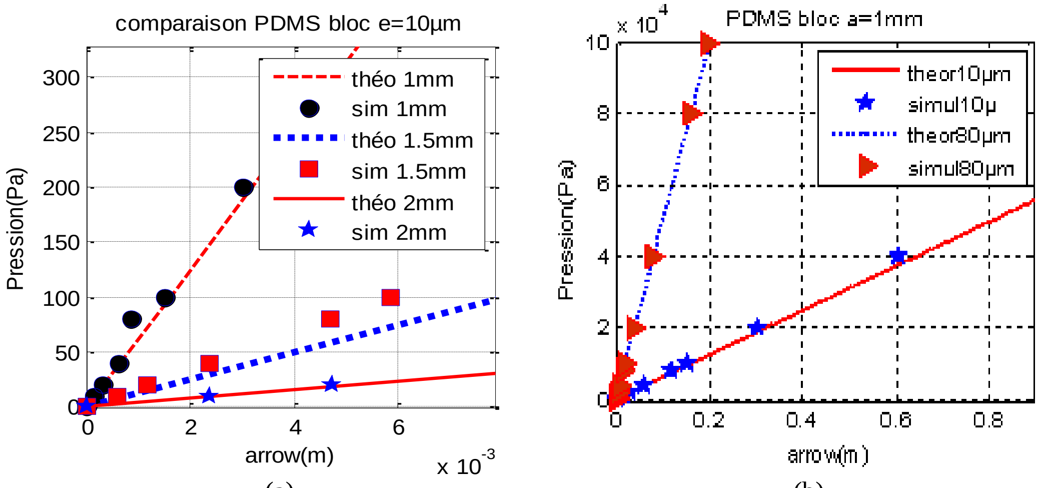


Fig.4. Microactuator

We have processed simulations of a membrane in PDMS encrusted in a bloc, and we obtained the results shown on figures 5 (a) and (b). [6]



(a) (b)

Fig. 5 Comparison between theoretic and simulation curves for a
(a) thickness : e= 10µm and différent rays a=1 ; 1,5 ; 2 mm
(b) ray a=1mm and différentes thickness e=10 ; 80 µm

From the previous curves,we notice that the simulation results are identical to the theoretic ones.

7. Results of simulation of a membrane in alliage bloc:

Our microactuator is shows in figure 6

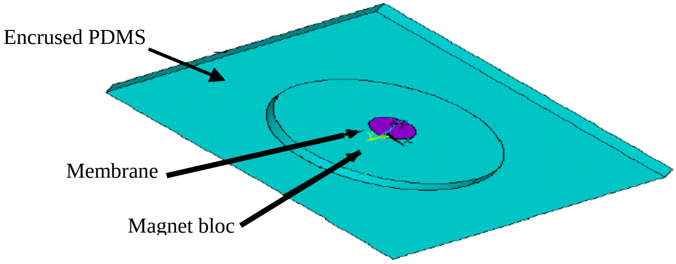


Fig. 6 Microactuator

In this case, we have added a magnet in the center of the membrane and the obtained results by simulation are shown on figure 7 ,where the effect of the magnet on the arrow is clairly shown[6] :

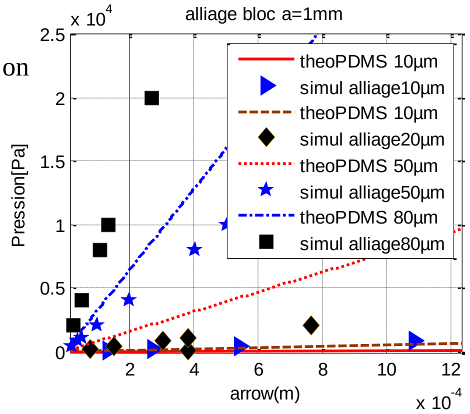


Fig. 7 Comparison between membranes in PDMS bloc and alloy bloc for a ray : a=1mm and different thicknesses : e=10 ; 20 ; 50 ; 80 µm

We notice that the arrow goes down in the case of a membrane in alloy bloc composed to the membrane in PDMS bloc. This is due to the magnet presence in the first membrane.

We have summarized the results of the simulation in figure 8:

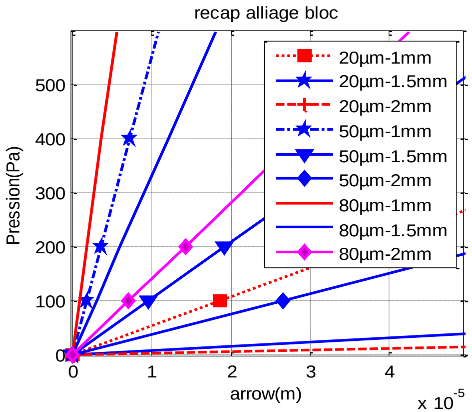


Fig. 8 Recapitulating curves ; arrow for membrane in alloy bloc

8. Results of the simulation of membrane in small magnet alloy

Our microactuator is shows in figure 9

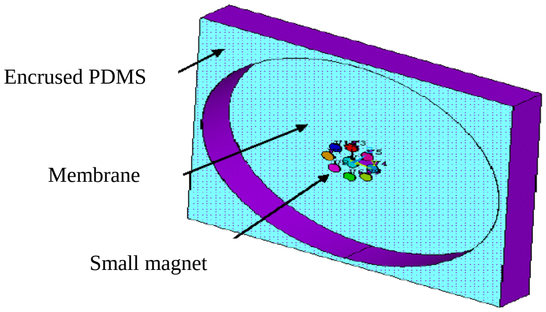


Fig.. 9. Microactuator

In this part , the magnet in bloc is divided in small magnets located equally in the centre of the membrane. The figure 10 gives a synthesis of this study:

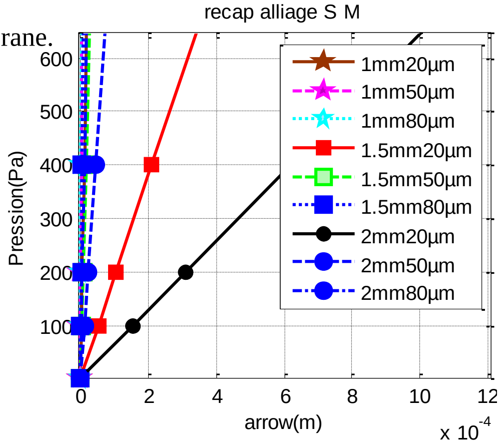


Fig .10. Recapitulating curves ; arrow for membrane in small magnet alloy

9. Interpretation

- The proportionality between the arrow and the ray is due to the fact that the deformation is a function of entropy of the PDMS chain. This entropy is evaluated from the probability per volume unit w(x,y,z) to find the edge of the other edge(point) of the chain in a point M (x,y,z) given in space, while the other edge is fixed to point O (see equation 4) [8]:

$$w(x,y,z)=\left(\frac{\beta}{\Pi}\right)^3\exp\left(-\beta^2r^2\right) \quad (4)$$

and

$$\beta=\sqrt{\left(\frac{3}{2}na^2\right)} \quad (5)$$

Where $r^2 = x^2 + y^2 + z^2$

Nomenclature

n maillon number in the chain
a length of maillon.

These segments behave essentially as independent chaines that allow the movement of the macromolecules ones to the other. In addition to the behavior of caoutchouc of PDMS favorize this moving and facilitates the membrane deformation

- We have remarked that the arrow goes down with the rising of the thickness .this is due to the effect of plastic compaction, that interprets the macromolecules, in addition to the Young modukus and the area that remains constant[8].

10. The effect of the magnets shape on the arrow

The figure 11 shows the effect of the magnet and its position on the shape of the center deformation of the membrane for the different structures [6]:

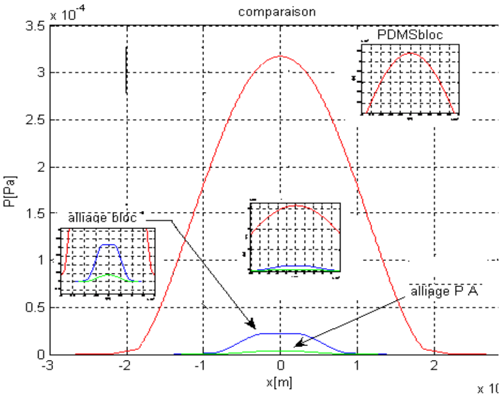


Fig. .11. Comparison of different structures

We notice that the deformation of the membrane in the alloy bloc is larger in case of membrane in alloy small magnet which a little bit near the membrane in PDMS.

The coming curve shows a comparison between the arrow of a membrane in alloy bloc and an other in alloy small magnet [6]

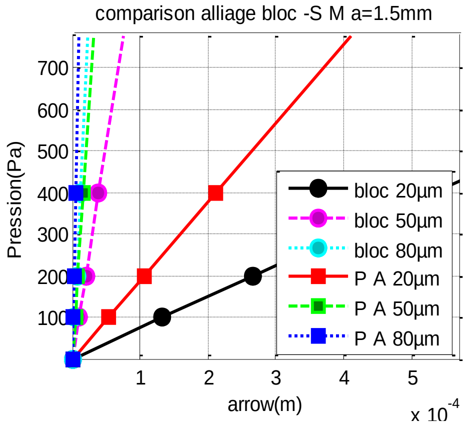


Fig. .12. Comparison between the arrow of a membrane in alloy bloc and alloy small magnet

In this figure , we remark that for the same value of pressure , the arrow of the membrane in alloy bloc is larger than that in small magnet alloy.

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