

Design and Analysis of a Microgripper in Microsurgery

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Abstract

This progress report presents two potential designs for a microgripper to be used in bio-medical applications. The two designs discussed are of a SMA microgripper and Conventional microgripper. The models were designed using Coventorware. The preliminary layouts, models and analysis have been presented below.

1. Project Definition Revised:

This progress report is an effort toward providing a short summary of the modeling and analysis performed for a Shape Memory Alloy (SMA) gripper and a Conventional Gripper. The final draft will deal with a comparison of these designs, from both the design and analysis viewpoints.

Also, design modifications will be proposed which will enhance the performance of the gripper. Enhancing the performance translates as maximizing the displacement at the tip with less gripping force applied.

2. Designs and Layouts:

SMA Microgripper:

The SMA microgripper was designed and analyzed and an effort was made to get results of the same magnitude as indicated in the paper by Roch *et al.* The design of the microgripper was done using the SUMMiT process. The process file was modified to accommodate the thickness of the structure. The model was also scaled down by a factor of 10 to make the layout and modeling possible using Coventorware.

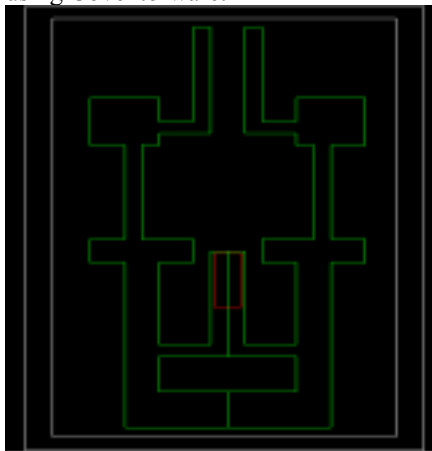
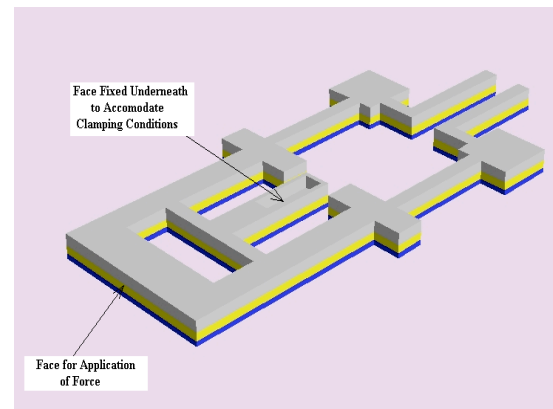


Fig 1:
Layout of a
SMA
microgripper

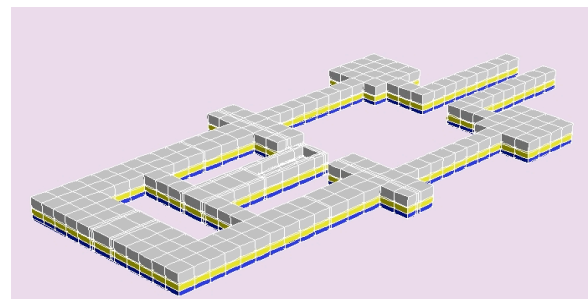
SMA needed to be added to the materials list. The only properties needed for the analysis were Young's Modulus, $E=4.02 \text{ GPa}$, Poisson's Coefficient=0.22 and the Density = 1190 kg/m^3 . The units for the above properties were converted into those used by the designer and analyzer modules in Coventorware. The initial gap for the SMA gripper is $200\mu\text{m}$ and on application of gripping force the gap widens to $400\mu\text{m}$. Hence, we are looking at the effective displacement of the gripper arms to be $200 \mu\text{m}$ on application of force. The layout for the SMA microgripper is as shown in Fig 1. The layout has three structural layers Poly1, Poly2 and Poly3. The Poly3 touches down to Poly0 and is anchored at that surface. The force and the clamping conditions are as shown in Fig 2.

Fig 2: Clamping and Application of Forces



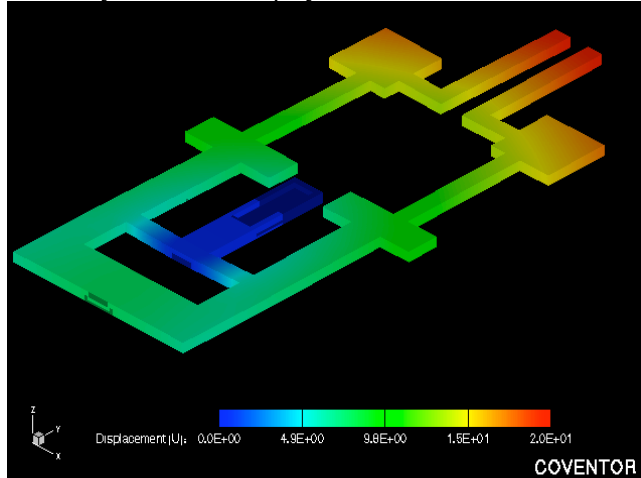
The model was meshed with Manhattan Mesh option using a linear mesh since the model was not complicated. The element sizes in the X, Y and Z directions were 50, 50 and 10 respectively. The mesh obtained is as shown in Fig 3.

Fig3: Meshed Model



Since the lengths were scaled down, arbitrary forces were applied to get a displacement of 20 μm (The lengths are scaled down by a factor of 10). The force obtained from the analysis was 1500 μN to yield a displacement of 20 μm at the tip of the gripper.

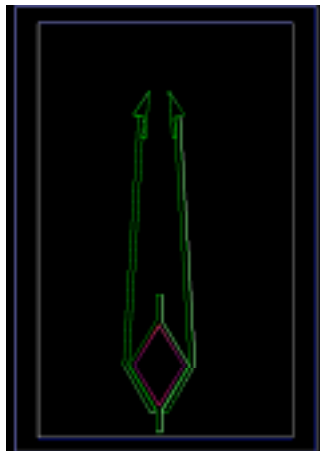
The analysis result is displayed below.



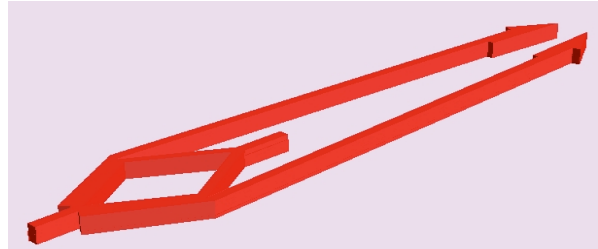
Although they don't specify which software they used for modeling the gripper, Roch *et al* performed the analysis using ANSYS 5.5.3 using Solid 45 3D elements.

Conventional Microgripper:

The conventional microgripper was also designed using the SUMMiT process. The layout of the gripper is done and a model has been successfully created. The layout of the gripper is as shown.



For simplicity, the arms of the microgripper are modeled as rigid links. The model was created and is shown below. The structure consists of Poly1, Poly2 and Poly3 stacked on top of each other. The angle contained by the flexural suspension to which the two arms are linked is 60°. The analysis results of this design will be documented in the final draft.



These two designs will be compared from both, the design and analysis viewpoints indicating the forces applied and corresponding displacements obtained at the tip of the microgripper. As indicated design modifications will also be suggested to enhance the performance in the final report.

References:

- [1] I Roch, Ph Bidaud, D Collard and L Buchailot, 2003, Fabrication and characterization of an SU-8 gripper actuated by a shape memory alloy thin film, *Journal of Micromech. Microengineering*.
- [2] S. Ku and S.E.Salcudean, 1996, Design and Control of a Teleoperated Microgripper for Microsurgery, *Proceedings of the IEEE International Conference on Robotics and Automation*.
- [3] M C Carrozza, A Menciassi, G Tiezzi and P Dario, 1998, The Development of a LIGA-microfabricated gripper for micromanipulation tasks, *Journal of Micromech. Microengineering*.

Schedule:	October			November			December		
	1	2	3	4	5	6	7	8	9
Literature Survey									
Project Definition									
Project Definition Revised									
Progress Report									
Analysis Of Future Designs									
Proposed Design Modifications									
Final Paper Draft									
(Design & Analysis)									