# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion:

- In terms of Amplitude of deflection in micrometer when the(200μm) length of cantilever covered with different positions of the electrode pad; it was found that the critical points(1μm) of the amplitude of deflection for the cantileverfor these different positions; occurswhen the pull-involtages between (32mV and 89mV) .as example the for 100% of cantilever covered with the electrode pad the applied voltage should not exceed (32mV) to avoid a critical point.
- The natural frequency decrease exponentially related to increase the upper electrode length.
- The amplitude of deflection increases exponentially with increase applied voltage and increase upper electrode position length.

## 5.2. Recommendation:-

For future work it is recommended that:-

- Using another semi-conductor material like germanium to build the actuators in order to obtain the most efficient actuator.
- Postgraduate mechatronics students can research in the effects of stresses, creep and fatigue in the operation of the actuator.
- The shape of actuator has high effect in the applied voltage which determine the electrostatic in the cantilever and because of that the shape can be changed, also the dimensions can be changed in order to obtain optimal design.
- the properties of material has a strongly affect in the value of natural frequency thus a material with high young modules and low density will give high value of natural frequency ,with consideration of electro static force amount.

# References:

**[1]**Stephen Beeby,GrahamEnsell,MichaelKraft,Neil White"MEMS Mechanical Sensors",2004,Library of Congress Cataloging-in Publication Data,British Library Cataloguing in Publication Data.

**[2]**A.R. Jha, Ph.D,"MEMS and Nanotechnology-Based Sensors and Devices for Communications, Medical andAerospaceApplications",2008,Library of Congress Cataloging-in-Publication Data.

**[3]**Myer Kutz,"Mechanical Engineers' Handbook (Instrumentation, Systems,Controls, and MEMS)", Third Edition, 2005,Published by John Wiley & Sons, Inc., Hoboken, New Jersey.Published simultaneously in Canada.

**[4]** Vijay K. Varadan,K. J. Vinoy,S. Gopalakrishnan,"Smart Material Systems and MEMS: Design and Development Methodologies",2006,British Library Cataloguing in Publication Data.

**[5]** Jan G. Korvink,Oliver Paul, "MEMS: A Practical Guide to Design, Analysis, and Applications",2006,William Andrew, Inc.,Springer-Verlag GmbH & Co. KG.

**[6]**Héctor J. De Los Santos,"Introduction to Microelectromechanical Microwave Systems"Second Edition, 2004,Library of Congress Cataloging-in-Publication Data,British Library Cataloguing in Publication Data.

**[7]** Mohammad I. Younis," MEMS Linear and Nonlinear Statics and Dynamics",2011,Library of Congress Control Number: 2011930834

**[8]**MinhangBao,"Analysis and Design Principles of MEMS Devices",First edition, 2005,Library of Congress Cataloging in Publication Data,British Library Cataloguing in Publication Data.

**[9]**H. Baltes, O. Brand, G. K. Fedder, C. Hierold, J. G. Korvink,
O. Tabata,"Advanced Micro &Nanosystems,(Enabling Technology for MEMSand Nanodevices)",Volume 1, 2004 published by Wiley-VCH,Library of Congress applied forBritish Library Cataloguing-in Publication Data,Bibliographic information publishedby Die Deutsche Bibliothek.

**[10]**NadimMaluf**,**Kirt Williams,"An Introduction to Microelectromechanical Systems Engineering",Second Edition,2004,Library of Congress Cataloging-in-Publication Data,British Library Cataloguing in Publication Data.

**[11]**M.Pustan, S. Paqual, v. Rochus, J - C. Golinval,"Effects of the Electrode Positions on the Dynamical Behaviour of Electrostatically Actuated MEMS Resonators",2011 12th. Int. Conf on Thermal, Mechanical and Multiphysics Simulation and Experiments in Microelectronics and Microsystems, EuroSimE 2011.

**[12]**Wen-Ming Zhang and GuangMeng,"Nonlinear Dynamic Analysis of Electrostatically Actuated Resonant MEMS SensorsUnder Parametric Excitation",IEEE SENSORS JOURNAL, VOL. 7, NO. 3, MARCH 2007.

**[13]**RAJESHWARI SHEEPARAMATTI1, S. V. HALSE2, K. M. VINAYAKA SWAMY1, SHIVASHANKAR A. HUDDAR1, and B. G. SHEEPARAMATTI1,"Pull-in Voltage Study of Microcantilever using ANSYS/Multiphysics and COMSOL/Multiphysics",J. Comp. & Math. Sci. Vol.3 (3), 288-293 (2012).

**[14]** Hassen M Ouakad, Mohammad I Younis and FadiAlsaleem,"Dynamic response of an electrostatically actuated microbeam to drop-table test",J. Micromech. Microeng. 22 (2012) 095003 (7pp).

**[15]**Laura Ruzziconi1, Ahmad M Bataineh2, Mohammad I Younis2,3, Weili Cui2 and Stefano Lenci1,"Nonlinear dynamics of an electrically actuated imperfect microbeam resonator:experimental investigation and reduced-order modeling",J. Micromech. Microeng. 23 (2013) 075012 (14pp).

**[16]**Fangrong Hu1, Yixian Qian2, Zhi Li1, Junhao Niu1, Kun Nie1, Xianming Xiong1, Wentao Zhang1 and Zhiyong Peng1,"Design of a tunable terahertz narrowbandmetamaterial absorber based on anelectrostatically actuated MEMScantilever and split ring resonator array",J. Opt. 15 (2013) 055101 (7pp).