

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

أَبِاسْمُكَ رَدِّكَ الَّذِي ذَلَّقَ الْإِنْسَانَ (1) أَنْ يَنْعَلِ مِنْهُ لَقِي (2)
أَوْ رَدِّكَ الْأَكْبَرِ وَالْأَكْبَرِ (3) لَمْ يَلْقَ لَمْ يَلْقَ (4) الْإِنْسَانَ أَنْ
يَلْمُ وَيَعْلَمُ (5)

صَدَقَ اللَّهُ الْعَظِيمُ

Dedication

To my mother who helps me so much and encourager me in my education,,,,,

To my father who makes life easy to achieve such works by improve my environment.

Acknowledgement

I would like to thanks administration of the Sudan University & all the staff of the faculty of the engineering who made effort to help me. Particular thank to the supervisor Dr/ Mussab Zaroug who gave me valuable information and guiding me. I would like to thank also Dr/ Mohamed Abdelaziz & teacher Aboubaker Khojali for assistance and help.

Abstract

A variety of the surface micromachined electrothermal microactuators have been widely applied in various areas due to the high force provided at a relatively low input voltage. A new optimized V-beam electrothermal micro actuator is proposed for providing angular displacement & output force. The design concept and preliminary simulation results of V-beam actuators are presented in this research. Due to its optimized structural design, this V-beam actuator capable of generating maximum angular displacement, output force and exhibits good characteristics with high-level performance for industrial applications.

This research employs particle swarm optimization method to search efficiently the optimal V-beam electrothermal micro actuator parameters of MEMS systems, as represented by the entropy generation rate. The proposed approach had superior features, including easy implementation, stable convergence characteristic, and good computational efficiency.

In this study, we use the proposed method to design v- beam width, thickness, length, gap between beam and substrate and current density to obtain minimum entropy generation rate, the results show that the output force can be increase about 40% compare to recent study.

المستخلص

مجموعات متنوعة من المشغلات الدقيقة الكهروحرارية تم استخدامها على نطاق واسع في مختلف المجالات نظرا لعلو قوتها المنتجة من فولتية منخفضة نسبيا. هذا البحث يقترح مشغل دقيق شكل حرف (V) بصورة مثلى للحصول على قوة خرج وأزاحة زاوية مثلى. مفاهيم التصميم ونتائج المحاكاة الأولية تم عرضها في هذا البحث .

في إطار التصميم الأمثل لهيكل المشغل الدقيق شكل حرف (V) سوف يكون قادرا على توليد ازاحة زاوية وقوة خرج عظيمتان ويعطى خصائص جيدة مع أداء رفيع المستوى لأغراض التطبيقات الصناعية. هذا البحث يستخدم طريقة سرب الجسيمات الأمثل (سرب الطيور) (PSO) للبحث بكفاءة مثلى عن المتغيرات التى تؤثر على المشغل الدقيق حرف (V) فى أنظمة المشغلات الكهروميكانيكية الدقيقة (MEMS) بأستخدام الأنتروبيا .

طريقة البحث عن الحل الأمثل تمتاز بالعديد من الخصائص المتفوقة تشمل سهولة التنفيذ، الأستقرارية، ميزة التقارب، والكفاءة الحسابية الجيدة.

فى هذه الدراسة تم استخدام الطريقة المقترحة (سرب الجسيمات) لتصميم العرض، السمك، الطول، الفراغ بين المشغل والقاعدة وشدة التيار للحصول على أقل معدل أنتروبيا ، النتائج اثبتت انه يمكن زيادة قوة الخرج 40% من الدراسة السابقة.

List of Abbreviations

sample	Define
MEMS	Micro-electromechanical systems
MST	Microsystems technology
MOEMS	Micro-optoelectromechanical
IC	Integrated circuit
HARM	High-aspect-ratio micromachining
PSO	Particle Swarm Optimization
EA	Evolutionary algorithms
GA	Genetic algorithms
EC	Evolutionary computation
ES	Evolution strategies
MINLP	mixed-integer nonlinear optimization problems
NA	Not Available

List of Symbols

sample	Define
\mathbf{X}	Particle position vector
\mathbf{v}	Particle velocity vector
\mathbf{W}	Inertia weight
\mathbf{pbest}	Best solution
\mathbf{gbest}	Best global solution
σ_1	cognitive learning rate
σ_2	social learning rate
\mathbf{rand}	random values
\mathbf{D}	Dimension
$\mathbf{T}(\mathbf{x})$	Temperature variation of V-beam.
\mathbf{x}	position along with the beam
\mathbf{J}	current density
ρ	resistivity of silicon
\mathbf{g}	gap between beam and substrate
\mathbf{h}	beam thickness
\mathbf{Ka}	Thermal conductivity, air
\mathbf{Ks}	Thermal conductivity, silicon
\mathbf{m}	mass of V beam
\mathbf{L}	V beam length
\mathbf{S}	Ratio of heat loss from sides & bottom of the V beam to heat loss from bottom only
\mathbf{P}	Electrical power
\mathbf{w}	V beam width
\mathbf{F}_t	output force of V beam
$\mathbf{U}(\theta)$	angular displacement
\mathbf{C}	Experimental correlation factor
\mathbf{E}	Young's modulus, silicon
\mathbf{d}	Density, silicon
α	Thermal expansion coefficient, silicon

List of figures

Figure NO	Figure Title	Page NO
Figure (2.1)	(a) A MEMS silicon motor together with a strand of human hair and (b) the legs of a spider mite standing on gears from a micro-engine.	8
Figure (2.2)	Classifications of microsystems technology.	9
Figure (2.3)	(a) the first commercial accelerometer from Analog Devices (1990); its size is less than 1 cm ² (left) and (b) capacitive sense plates, 60 microns deep (right) .	12
Figure (2.4)	(a) Disposable blood pressure sensor connected to an IV line, (b) disposable blood pressure sensors (as shipped) and (c) intracranial catheter-tip sensors for monitoring blood pressure during cardiac catheterization, shown on the head of a pin .	13
Figure (2.5)	Thermal inkjet print technology.	13
Figure (2.6)	PSO flow chart.	20
Figure (3.1)	(a) Schematic drawings of V-shaped beam actuator of High-aspect ratio structure. (b) V-shaped beam deformed in the arched direction owing to a dc bias.	23
Figure (3.2)	PSO implementation by MATLAB program flow chart.	28
Figure (4.1)	Shows Variation of the optimum entropy generation rate and optimum V beam thickness (h) during iterations.	35
Figure (4.2)	Shows Variation of the optimum entropy generation rate and optimum gap between beam & substrate (g) during iterations.	36
Figure (4.3)	Shows Variation of the optimum entropy generation rate and optimum V beam width (w) during iterations.	37
Figure (4.4)	Shows Variation of the optimum entropy generation rate and optimum V beam Length (L) during iterations.	38
Figure (4.5)	Shows Variation of the optimum entropy generation rate and optimum V beam current density (J) during iterations.	39

List of tables

Table NO	Table Title	Page NO
Table (2.1)	Applications of MEMS.	11
Table(3.1)	Parameters used in analytical modeling of V-beam.	22
Table (4.1)	Gives the summarized results for parameters and obtained values by applying PSO method.	40
Table (4.2)	Gives the summarized results of PSO method compared to Chengkuo Lee results	44

Contents

Topic	page
الآية	I
Dedication	II
Acknowledgement	III
Abstract	IV
المستخلص	V
List of Abbreviations	VI
list of Symbols	VII
List of figures	VIII
List of tables	IX
Content	X-XI
Chapter one: Introduction	
1. General introduction.	1
1.1. Problem Statement.	3
1.2. Objective.	3
1.3. Methodology.	3
1.4.thesis outline	3
Chapter two: Micro-electromechanical systems & particle swarm optimization overview	
2.1. Literature Review	5
2.2. MEMS definition.	7
2.2.1. MEMS Classifications.	9
2.2. 2. MEMS Applications.	11
2.2.3. Established MEMS Applications.	12
2.3. Optimization Techniques.	14
2.3.1. Particle Swarm Optimization (PSO).	16
2.3.1.1. The Structure of PSO.	17
2.3.1.2. The Trajectory of a Particle.	18
Chapter three: V-shaped beam design and simulations	
3. V-shaped beam design and simulations:	21
3.1. Mathematical model.	24
3.2. PSO consideration.	25
3.2.1. Parameter x_1 .	25
3.2.2. Parameter x_2 .	26
3.2.3. Parameter x_3 .	26

3.2.4. Parameter x_4 .	26
3.2.5. Parameter x_5 .	27
3.3. MATLAB code.	27
3.3.1. PSO implementation.	28
3.3.2. Test function.	32
Chapter four: Results and discussion	
4. Results and discussion.	33
4.1. Parameter x_1 : V beam thickness (h).	35
4.2. Parameter x_2 : gap between beam & substrate (g).	36
4.3. Parameter x_3 : V beam width (w).	37
4.4. Parameter x_4 : V beam length (L).	38
4.5. Parameter x_5 : V beam current density (J).	39
4.6. Example of PSO implementation for parameter x_1	40
Chapter five: Conclusion and Recommendations	
5. Conclusion and Recommendations	45
5.1. Conclusion	45
5.2. Recommendations	47
Reference	48
Appendices	54