Multiphysics Modeling and Simulation of MEMS Based Thermal Bimorph Sensor Array for Automated Solar Energy Storage Applications

Excerpt from the Proceedings of the 2011 COMSOL Conference in Bangalore

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Glimpses of Presentation

- Introduction
- Thermal bimorph array
- Design concept
- Simulation
- Results
- Conclusion

Objective

- Design and Development of Thermal bimorph array sensor
- Meet the growing needs of industry
- Using the renewable resources efficiently.

Introduction

- Solar energy – Evergreen resource.
- Need for a novel idea.
- Design of thermal bimorph array.
- Purpose.
- Parameters for the design.

Solar energy

- Amount of solar energy

  [(intensity of radiation at outer regions of the earth's atmosphere)+(radiation reaching the earth's surface)]/2.

- Absorbing energy=68W/m^2 .
- Reflecting energy=72W/m^2 .
- 3.2 million EJ =>7000 times that of global energy consumption.
- 1% of solar energy can solve energy problems.
- 0.014% of solar energy->2005.
- 0.051% is expected in 2100.

SOLAR CONSTANT

- Intensity of solar radiation => 1369W/m² .

$$R = \frac{S\pi r^2}{4\pi r^2} = \frac{1369}{4} \approx 342\frac{W}{m^2}$$

- {Total solar radiation
  = [solar constant * cross sectional area]}.

Thermal actuator

- Capable of both unidirectional and bidirectional actuation.

- Promising solution to the need for large and linear displacement, low power MEMS actuator.

- Advantages compared to electro statically driven actuators.

SOLAR INTENSITY DISTRIBUTION

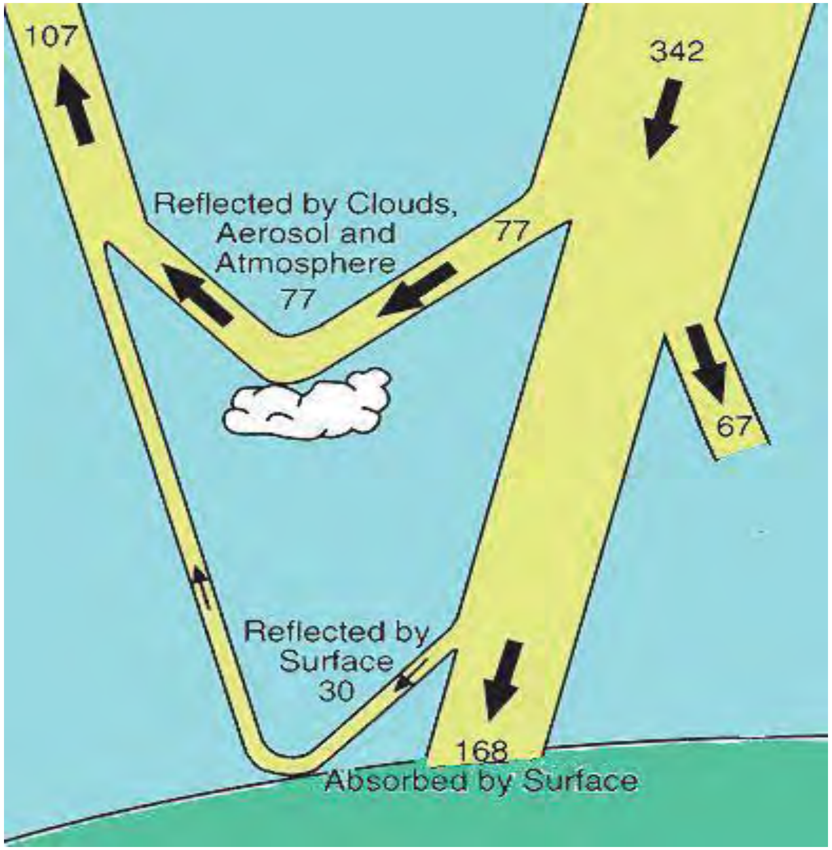


Fig 1 solar intensity distribution

- Upper region of the atmosphere recieves 342 W/m^2 of solar radiation.
- 30 W/m^2 is reflected back.
- 31% of incoming radiation is reflected back

Intensity Of Radiation Through Out The World

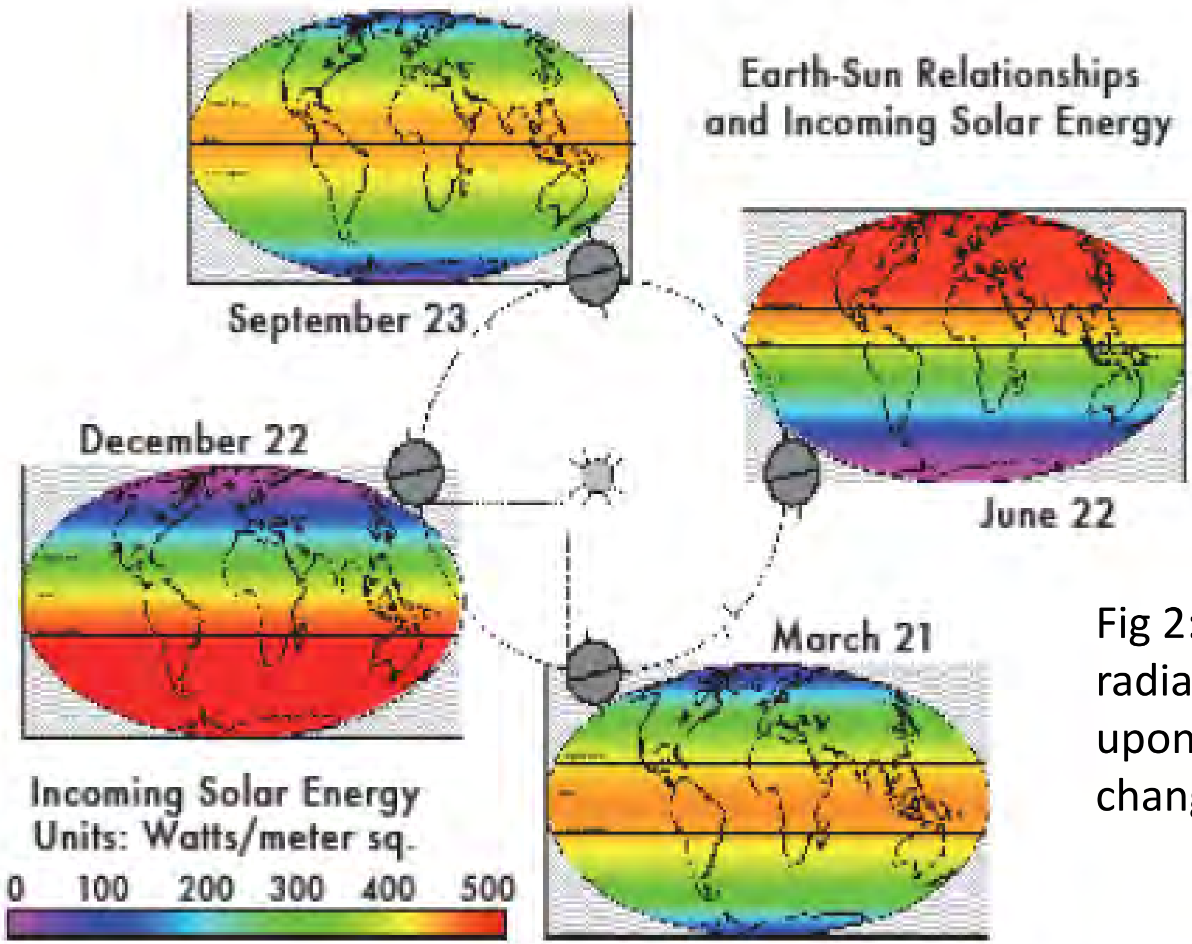


Fig 2:Intensity of radiation depending upon season changes.

DESIGN CONCEPTS

Design Of Thermal Bimorph Array

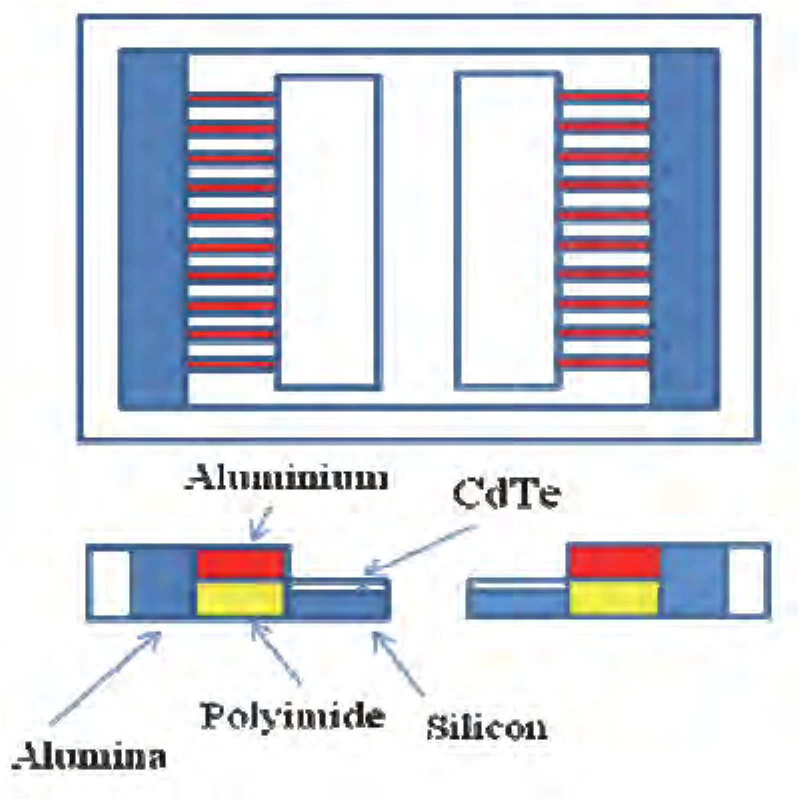


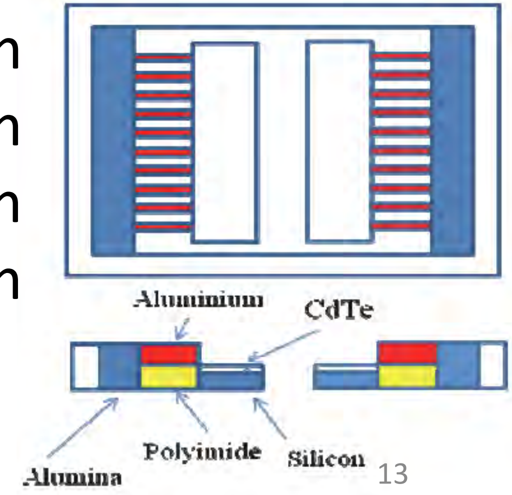
Fig.3 Schematic Diagram of Thermal Bimorph Array

Thermal properties of Materials

Property	Al	Polyimide
Thermal conductivity	237[W/m*K]	0.15[W/m*K]
Heat Capacity	904[J/kg*K]	1100[J/kg*K]
Coefficient of thermal expansion	230e-6[1/K]	5.5e-5[1/K]
Density	2700[Kg/m^3]	1300[Kg/m^3]

Design Parameters

Parameters		Value
Total frame length	-	1.3mm
Bimorph actuator length	-	200µm
Micro Plate length	-	1.05mm
Width of the micro plate	-	200 µm
Width of the total frame	-	10µm
Width of the thermal insulation	-	100µm
Thickness of thermal insulation	-	10µm
Thickness of high CTE material	-	5µm
Thickness of low CTE material	-	5µm
Thickness of microplate	-	3µm
Thickness of thin film	-	2µm



Geometry Model

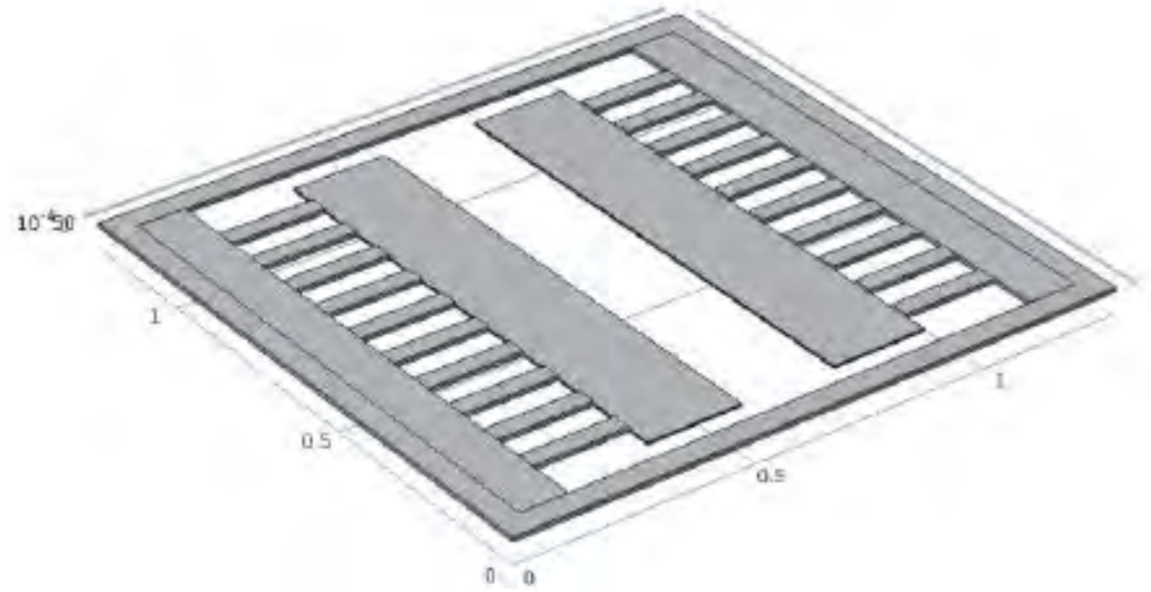


Fig .4 Geometry Model of Bimorph Array

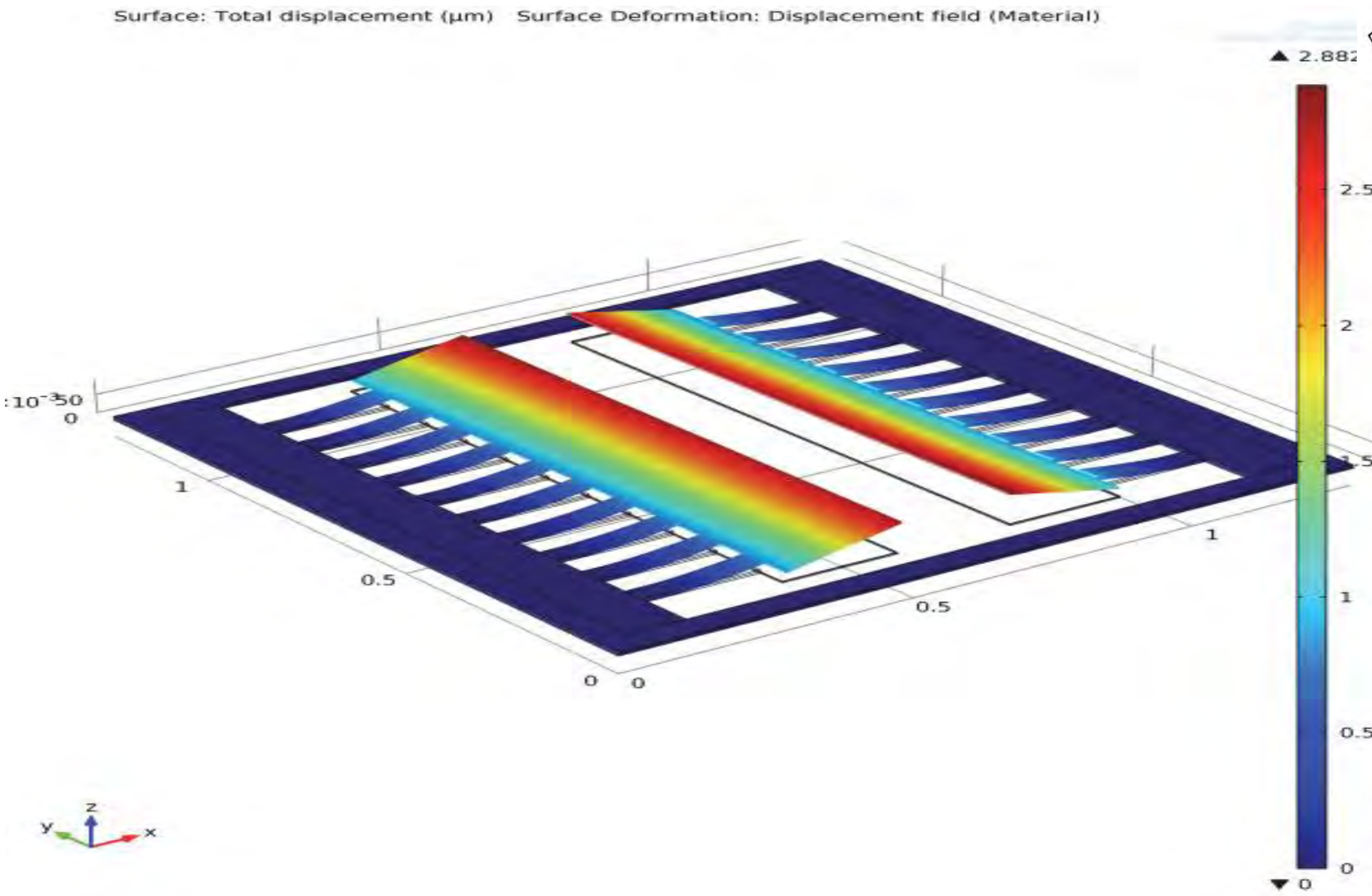
Simulation

Software used - COMSOL Multiphysics 4.1

Physics Applied - Thermal Stress

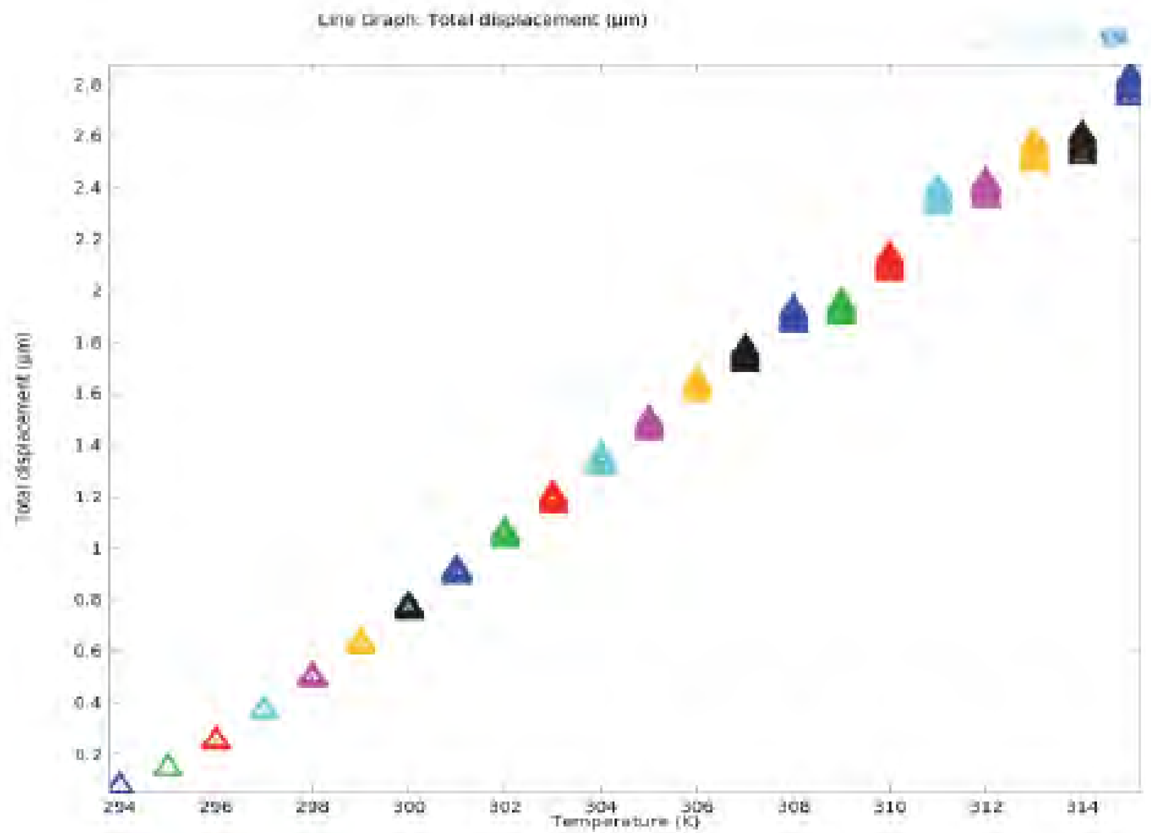
Mesh - Free Tetrahedral

Results And Discussions



Total Displacement microplates

Results And Discusions



TEXT [K]	Total displacement [μm]
294	0.0775
295	0.1475
296	0.2578
297	0.3778
298	0.5098
299	0.6435
300	0.7852
301	0.9257
302	1.0732
303	1.2162
304	1.3674
305	1.5079
306	1.6603
307	1.7884
308	1.9408
309	1.9665
310	2.1499
311	2.4124
312	2.4381
313	2.5923
314	2.621
315	2.8824

External Temperature (K) vs. Total Displacement (μm)

Conclusion

A maximum displacement of 2.88μm has been achieved with a micro device of dimension 200μm×40μm ×5μm in size.

The changes owing to temperature and displacement are studied and plotted.

Shows the deflection without any influence of external electrical source.

The designed model is achieved to receive maximum energy from the sun and which can be used to store the energy in batteries.

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Acknowledgement

COMSOL Multiphysics Pvt. Ltd., Bangalore.

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