Modeling of MEMS Based Bolometer for Measuring Radiations from Nuclear Power Plant

COMSOL CONFERENCE BANGALORE2013

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Introduction

- Bole- ray.

- It is thermal infrared sensor that measures the power of incident radiations.

- Types

  – Resistive

  – Hot electron

  – Micro bolometer

- Working principle – Thermal expansion of materials.

Designing

COMSOL software tool

- The software package selected is COMSOL MultiPhysics 4.3 a.

- Powerful interactive environment for modeling of various devices

- Four fundamental steps for designing using COMSOL software

    (1) Defining Geometry

    (2) Adding Materials

    (3) Adding Physical Interfaces

    (4) Meshing, Simulation

Geometry details

- Width of the substrate-100μm

- Depth of the substrate- 100μm

- Height of the substrate- 11μm

- Width of the metal plate- 45μm

- Depth of the metal plate- 20μm

- Height of the metal plate- 1μm

- Width of the copper link- 10μm

- Depth of the copper link- 20μm

- Height of the copper link- 13μm

- Width of the central support- 20μm

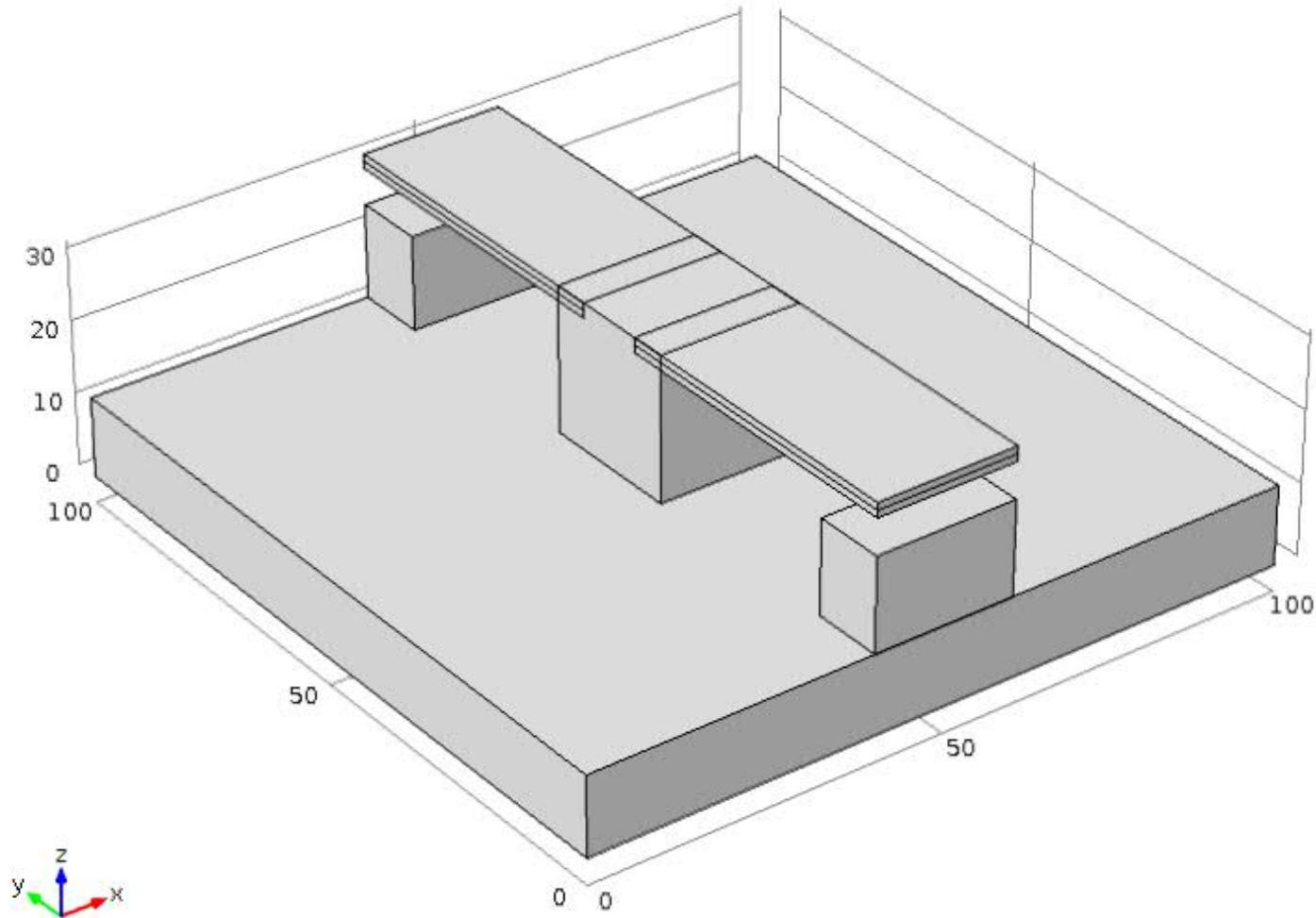- Depth of the central support 20μm

- Height of the central support 20μm

Figure 1: Designed model of bolometer

- Initially base of width 100μm, depth 100μm and height 11μm is built.

- Central support of width 20μm, depth 20μm, and height 20μm is built at the centre of the base.

- Two links of width 10μm, depth 20μm and height 13μm is built on the edges of the base.

- Two metal plates of width 45μm, depth 25μm and height 1 μm are built on either sides of the central support.

- Finally the union of 8 blocks is formed.

Addition of materials

- – Silicon -base and central support.
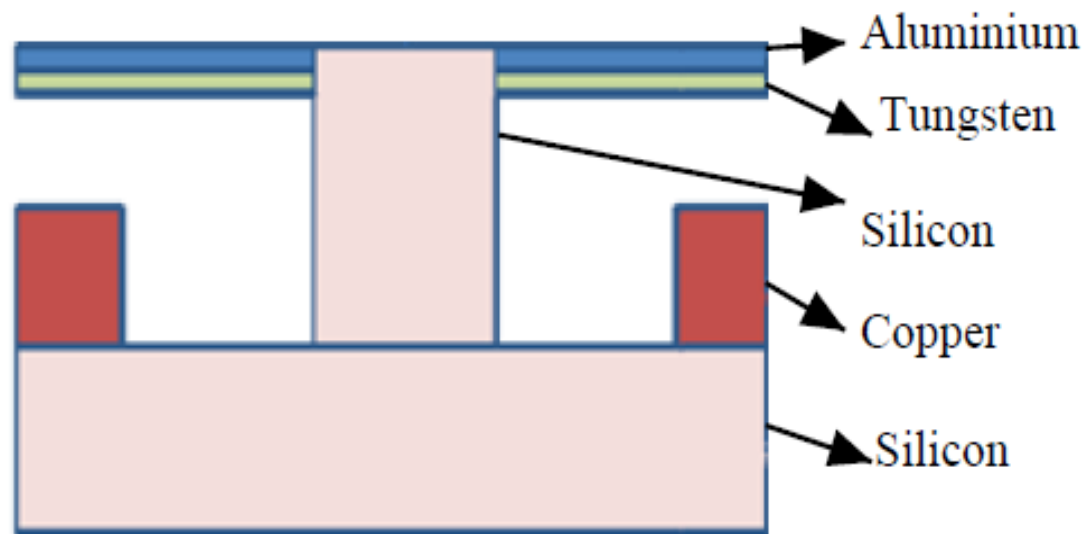- – Copper- two links.
- – Aluminum, Tungsten-plates.

Figure 2: Structural details of bolometer

Property	Value
Thermal conductivity	160[W/mK]
Heat capacity	900[J/kg×K]
Coefficient of thermal expansion	23M[1/K]
Heat Density	2700[Kg/m^3]

Table 1:Thermal properties of aluminium

Property	Value
Thermal conductivity	173[W/mK]
Heat capacity	1340[J/kg×K]
Coefficient of thermal expansion	4.5M[1/K]
Heat Density	17800[Kg/m^3]

Table 2: Thermal properties of tungsten

Physical interfaces:

- This model is carried out based on:

  - Joule heating and

  - Thermal expansion

- Facilitates for coupling of thermal, electrical and structural analyses.

- Relates the change in a material's linear dimensions to a change in temperature

Simulation

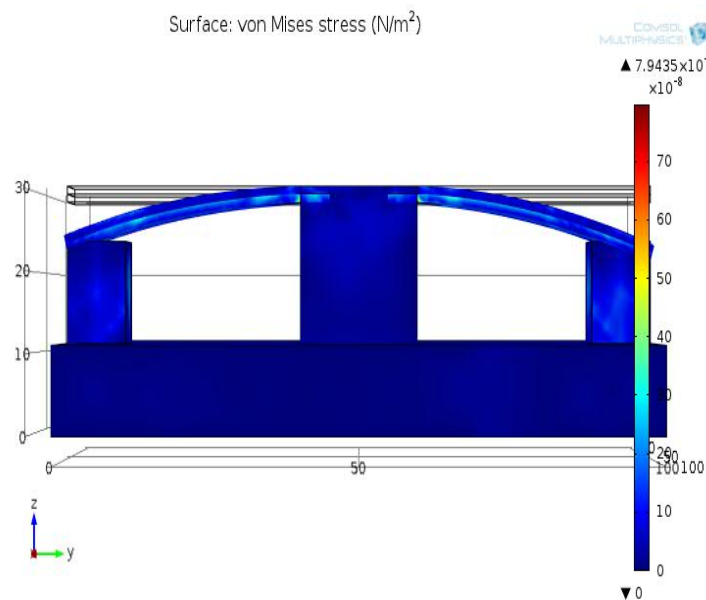- After design process, the proposed bolometer has been simulated to study the pressure distribution .
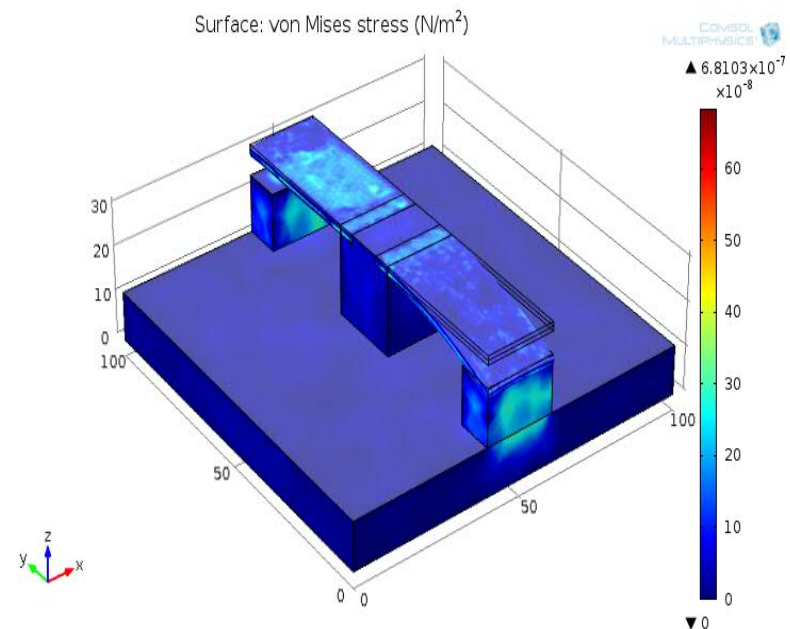

Figure 3: Pressure Distribution(front view)

Figure 4: Pressure Distribution (side view)

Results and analysis

- Aluminium plate deforms and touches the copper link.

- Maximum stress found to be 7.9435×10^{-7} N/m$^{2.}$

- This changes the resistance of the absorptive element.

- Increase in pressure, increases the deformation of metal plate.

- Thus the deformation occurs in metal plate causes change in resistance due to change in temperature.

- By measuring the change in resistance of the metal one can determine the intensity of the incident radiation

Conclusion

- Resistive micro bolometer has been designed using COMSOL 4.3 a. Specifically. the stress distribution across aluminium metal surface is studied.

- The maximum stress is found to be 7.9435 x 10^{-7} N/m^2.

- These studies would be useful in making of bolometers that prevent the people from powerful radiations.

References

1. Frank Niklaus, Christian Vieider, Henrik Jakobsen MEMS-Based Uncooled Infrared Bolometer Arrays – A Review.

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3. R. Reichle, T. Nishitani, E.R. Hodgson, L.C. Ingesson, E. Ishitsuka, S. Kasai, K.F. Mast, T. Shikama, J.C. Vallet, S. Yamamoto, Radiation hardness test of mica bolometers for ITER in JMTR, in: 28th EPS Conference on Contr. Fusion and Plasma PhysFunchal, 2001.

THANK YOU

Queries???