SMA Thin-Film Simulation in COMSOL Multiphysics

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# Objective

To design and simulate a Nitinol (Ni-Ti) Thin-Film in COMSOL Multiphysics.

# Equipment Required

PC with COMSOL Multiphysics installed.

# Procedure

## Initial Setup

1. Launch *COMSOL Multiphysics* software and select *Model Wizard.*
2. **Select *Space Dimension*:** *3D*
3. **Select *Physics*:** *Structural Mechanics* *Joule Heating and Thermal Expansion*
4. **Select Study:** *Stationary*
5. **Define *Units*:** *µm*

## Create Thin-Film Geometry

1. Right-click *Geometry Block*
2. Set the *Dimensions* as required

## Add Material

1. Under the *Add Material* tab, browse to *Material Library Nickel Alloys Ni-Ti (shape memory)* and click *Add to Selection.* Then select the *Thin-Film* geometry.
2. Define the *Material Properties* by entering appropriate values in the table.

## Apply Boundary Conditions

1. *Solid Mechanics Fixed Constraint* on one of the side faces of the thin-film
2. *Heat Transfer in Solids Temperature* (293 K) on the fixed face of the thin-film
3. *Electric Currents Ground* on the fixed face of the thin-film
4. *Electric Currents Terminal* (0.5 A) on the free face of the thin-film

## Mesh

1. Define *Mesh Element Size*. Note that finer mesh gives more accurate results but requires more computation time.
2. Click *Build All* to apply the mesh.

## Compute the Study

1. Click on *Compute* button to compute the study.

## Define Custom Results

1. Right-click on *Results* and select *3D Plot Group.* Rename the study as required.
2. Right-click on the newly created *3D Plot Group* and select *Surface.*
3. Dropdown the *Expressions* tab and select the required analysis (e.g. Solid Mechanics Displacement Total Displacement).

## Visualize the Results

1. Visualize the results by clicking on the respective *3D Plot Groups.*
2. The results can be saved to a file by clicking on *3D Image* button in top pane.

For a detailed video tutorial, please visit <https://youtu.be/zd5Mn7qefvg>.

# Results

|  |  |  |
| --- | --- | --- |
|  |  |  |
| von Mises Stress | Temperature Gradient | Isothermal Contours |
|  |  |  |
| Electric Potential | Total Displacement | Vertical Displacement |

The maximum total displacement when 0.5 A current was flown through the SMA Thin-Film was 1.4E3 µm.

The maximum vertical displacement when 0.5 A current was flown through the SMA Thin-Film was 8 µm.

# Appendix: Nitinol Properties

|  |  |  |  |
| --- | --- | --- | --- |
| **Property** | **Variable** | **Value** | **Unit** |
| Density |  | rho(T[1/K]) | Kg/m3 |
| Thermal Conductivity |  | 18 | W/m.K |
| Heat Capacity at Constant Pressure |  | 837.36 | J/kg.K |
| Electrical Conductivity |  | 12195 | S/m |
| Relative Permittivity |  | 1 | 1 |
| Coefficient of Thermal Expansion |  | 11E-6 | 1/K |
| Young’s Modulus |  | E(T[1/K]) | Pa |
| Poisson’s Ratio |  | 0.33 | 1 |