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REALIZING TOMORROW'S TECHNOLOGY

COMSOL CONFERENCE 2015 BOSTON

Multiphysics Analysis of Infra Red Bolometer

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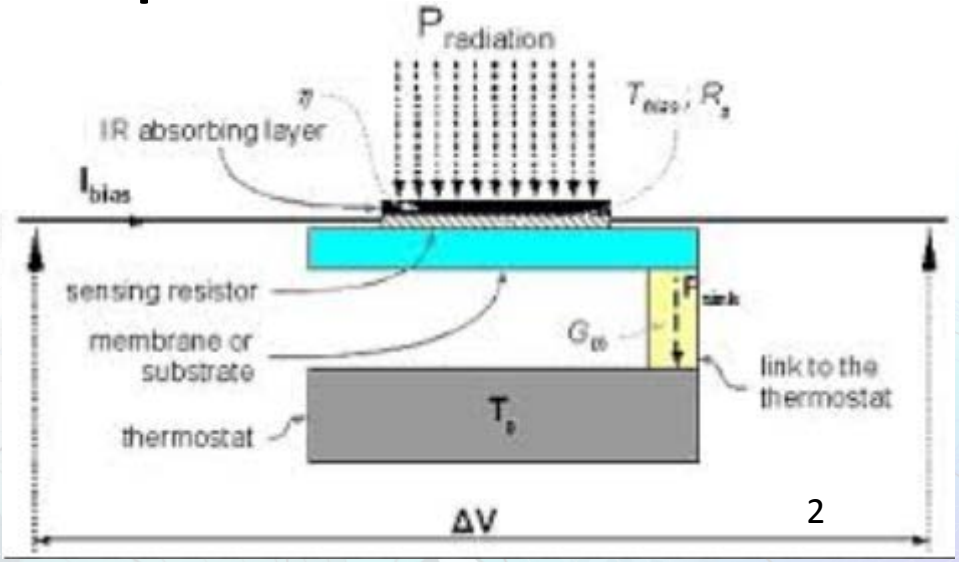
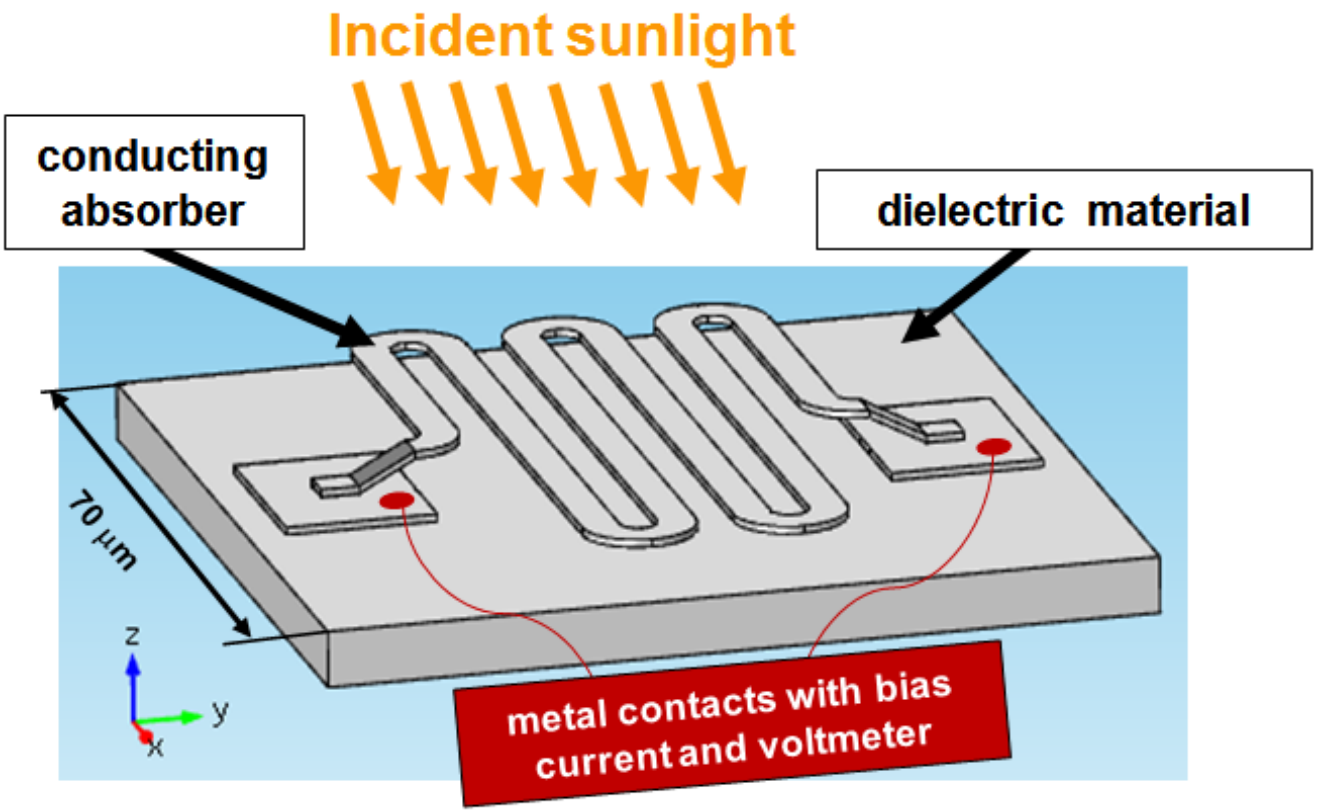
Background

- **Bolometer**
  - **Measures power of incident electromagnetic radiation**
  - **Heat material with temperature dependent electrical resistance**
  - **Temperature changes ~10^-4 C**
  - **Nuclear physics, night vision, astronomy**

- **Material temperature rises**
- **Electrical conductivity falls**
- **Changes reference potential**



Bolometer geometry/materials



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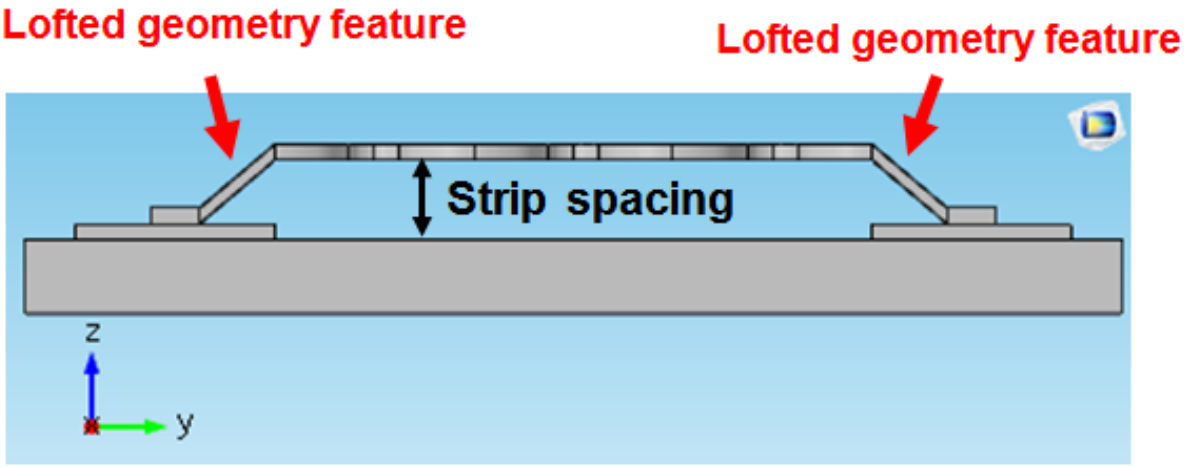
Parameterized Geometry



Geometry side-view with lofted geometry feature enabling automatic parametrization of strip spacing and computation of sensitivity with respect to strip spacing.

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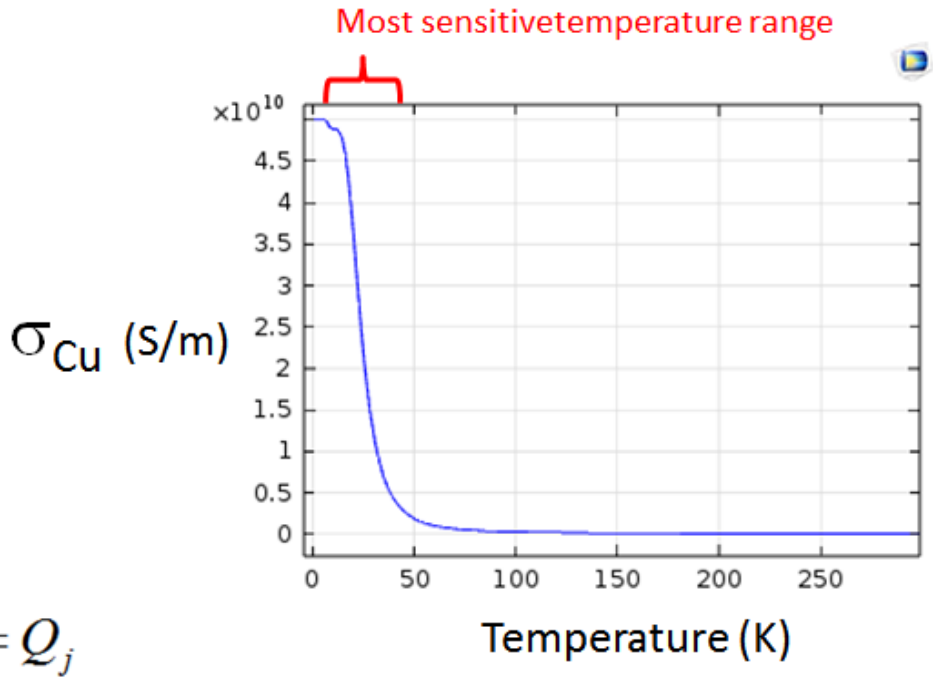
Model set-up

- **Physics**
  - **Radiation**
  - **Heat transfer**
  - **Conservation of electric current**
- **Governing equations and physics couplings**

Electric Currents: $\nabla \cdot \left(\sigma \nabla V - \mathbf{J}_e\right) = Q_j$

Heat Transfer: $\nabla \cdot \left(k \nabla T\right) = Q$

- **Material properties**



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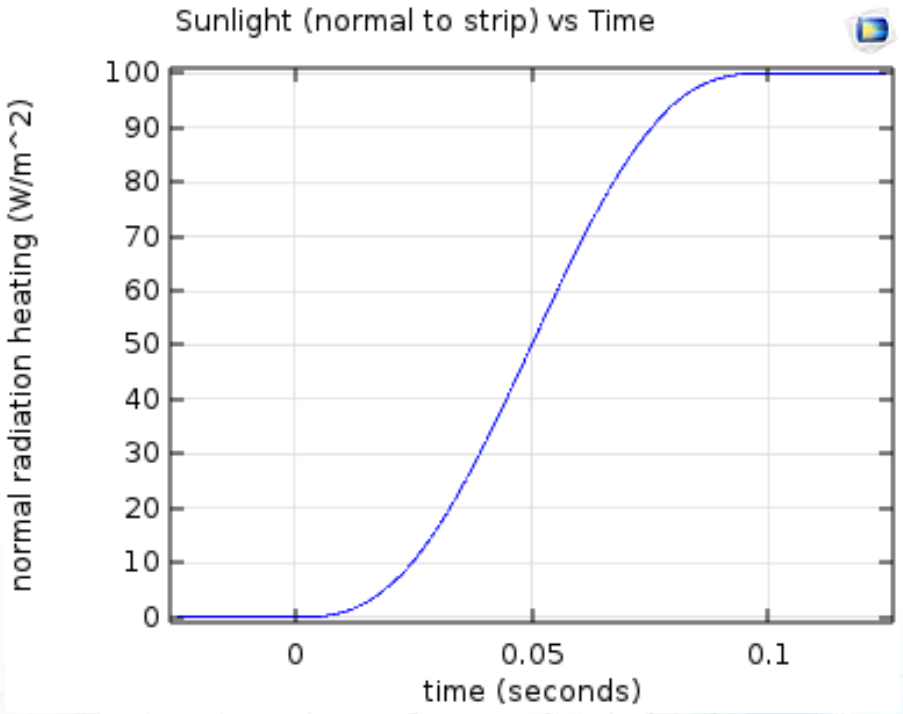
Model input

- **Radiation exposure**
  - **Solar position as function of latitude and longitude, date, time of day**



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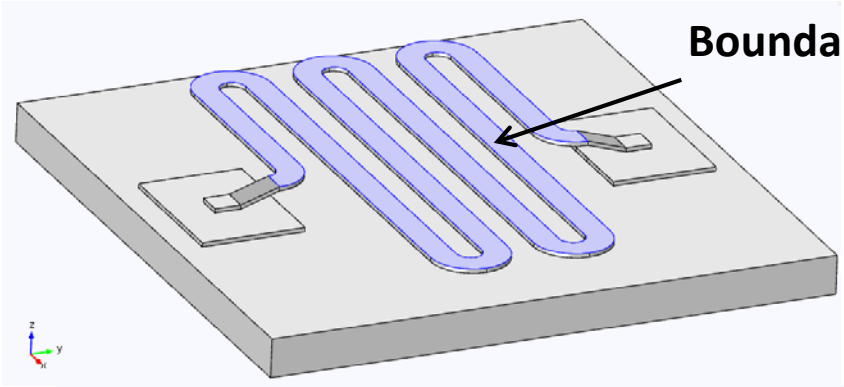
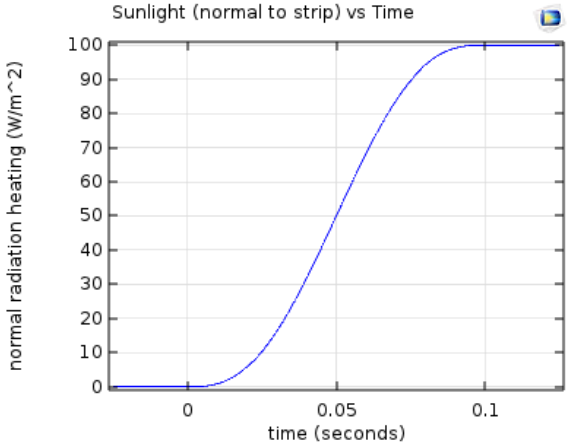
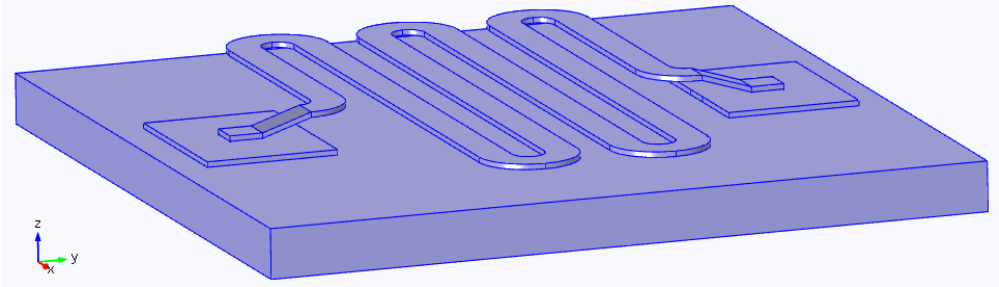
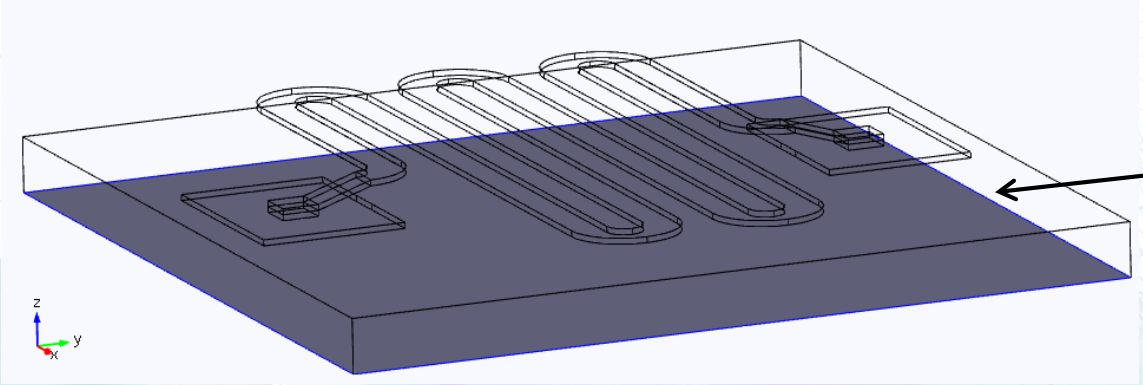
Boundary conditions: Heat Transfer





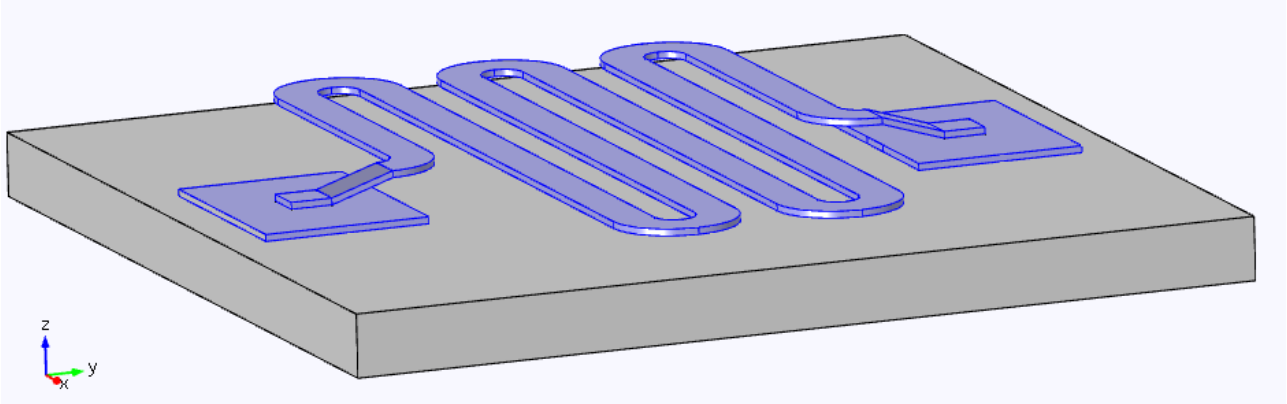


Convective heat cooling (h = 10 W/m^2/K, Sink temperature = operating temperature)

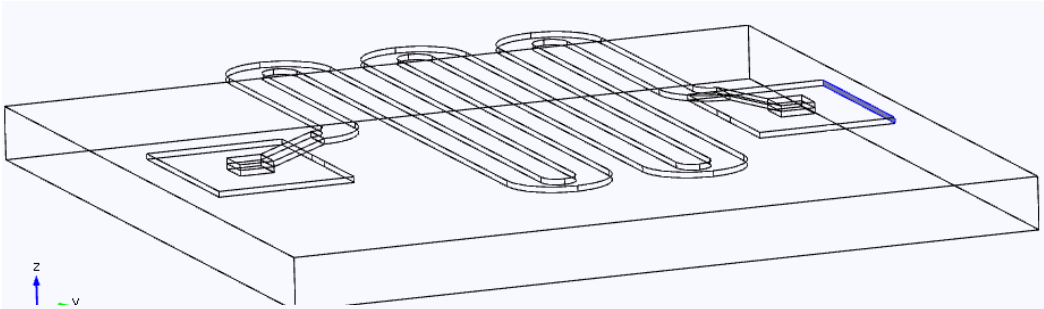


Fixed temperature set to the operating temperature parameter on the bottom boundary

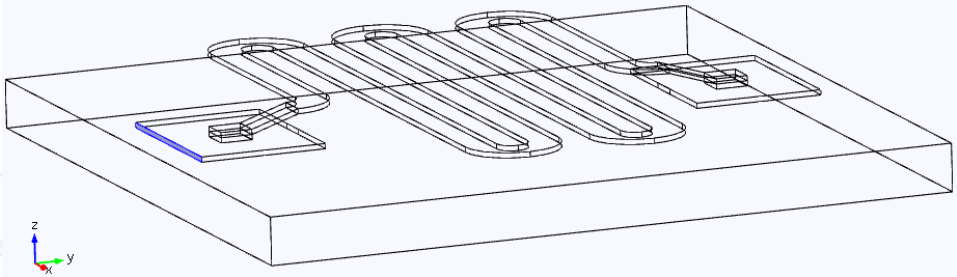
Boundary conditions: Electric currents



Electric insulation (normal current density is zero)



Bias current terminal boundary condition set to the bias current parameter (Typically ~ 100 μA)



Electric ground (V=0)

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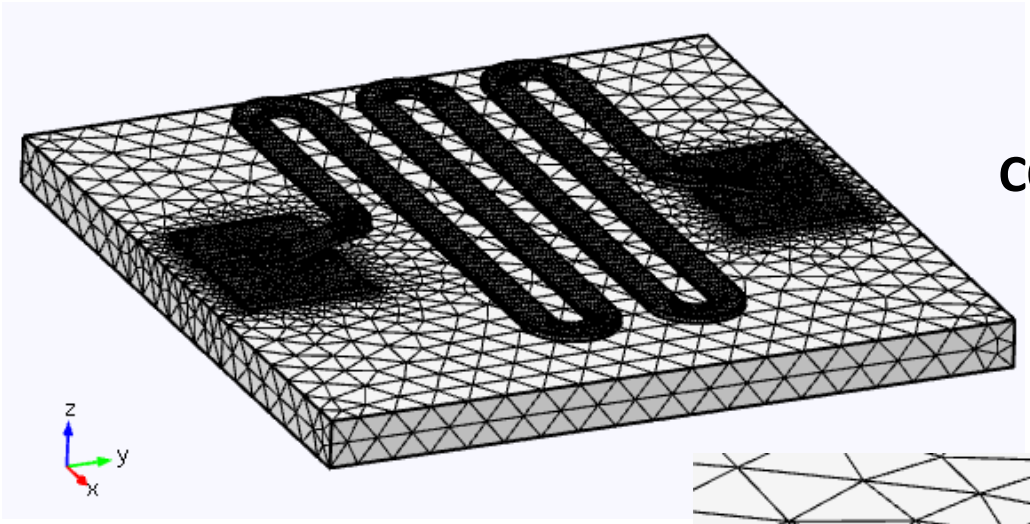
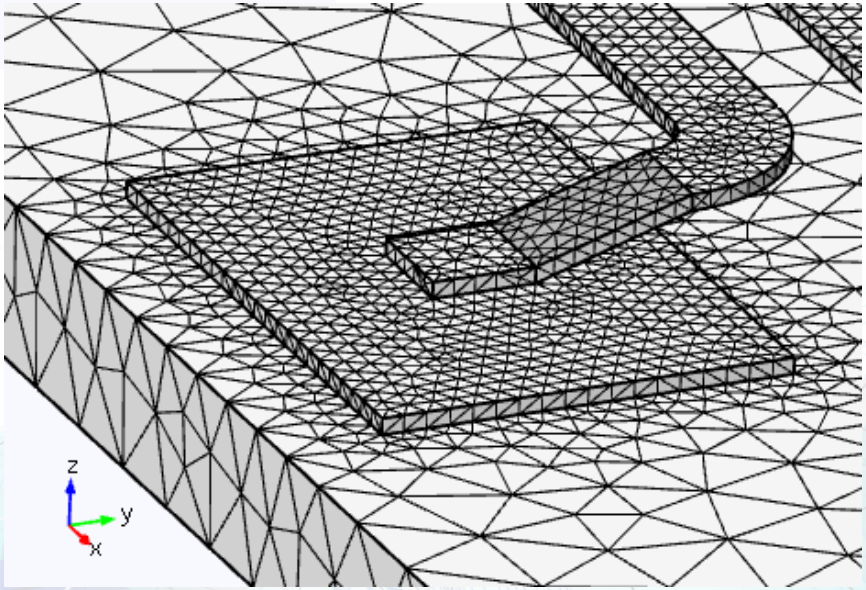
Meshing



COMSOL free tetrahedral meshing



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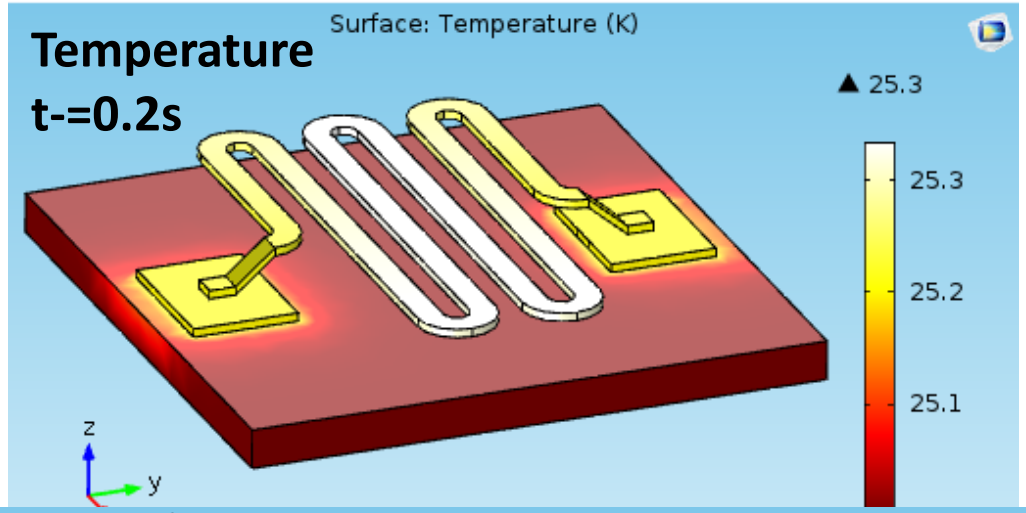
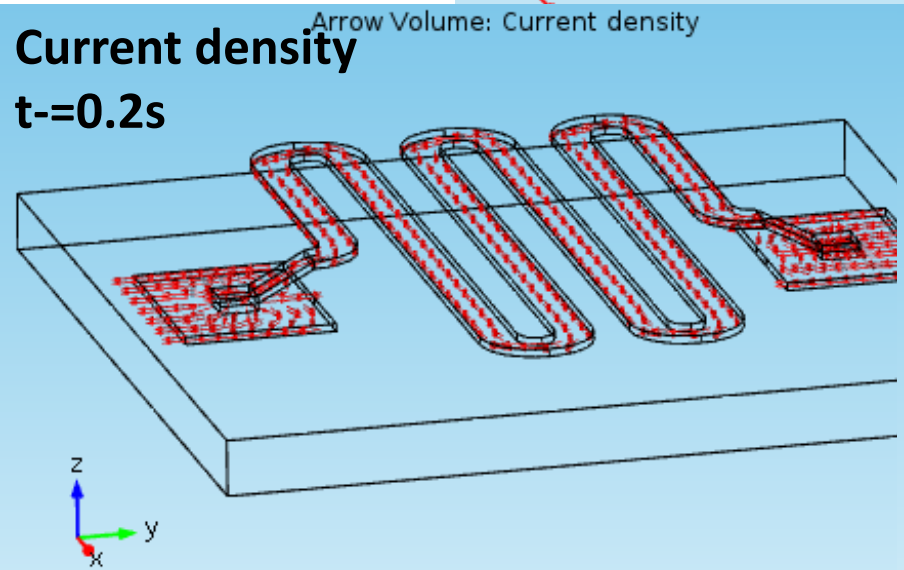
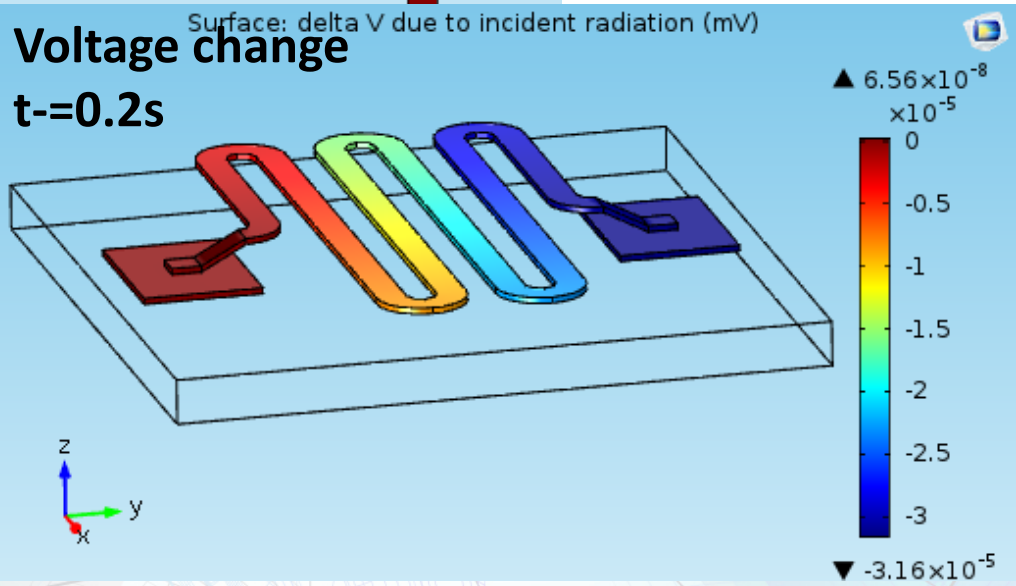
Results

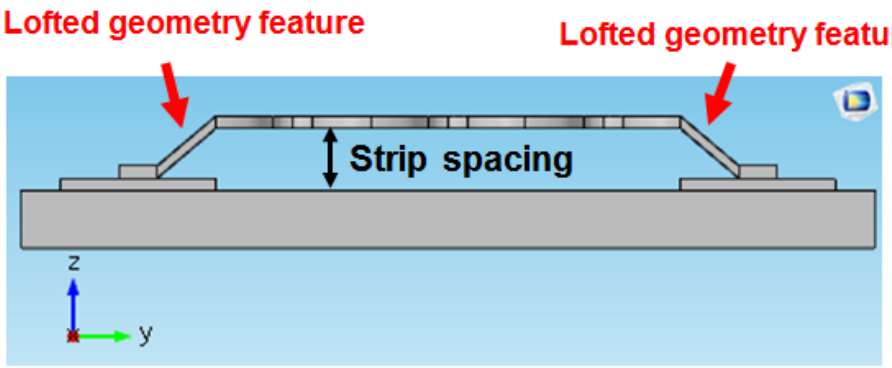

Surface: Temperature (K)
Temperature
t-=0.2s
▲ 25.3
25.3
25.2
25.1
z
y

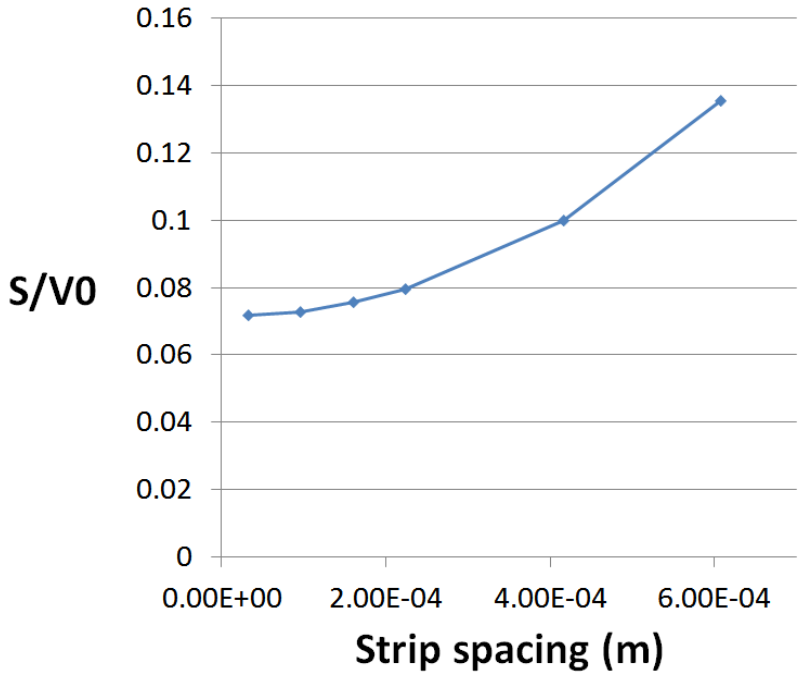

Arrow Volume: Current density
Current density
t-=0.2s
z
y
x


Surface: delta V due to incident radiation (mV)
Voltage change
t-=0.2s
▲ 6.56×10^-8
×10^-5
0
-0.5
-1
-1.5
-2
-2.5
-3
▼ -3.16×10^-5
z
y
x

Design sensitivity

Change in potential as a function of strip spacing





$$S = \frac{dV_{voltmeter}}{dW_{absorbed}}$$

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Summary

- **Model for use with optimizing bolometer design:**
  - **Serpentine geometry**
  - **Bias current**
  - **Material selection**
  - **Incident power**

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