Multiphysics Analysis of an Infrared Bolometer

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Abstract

Bolometers are used in a number of applications including night vision cameras, astronomy, and particle physics to measure the power of incident electromagnetic radiation. The general principle of operation is shown below: a strip of conducting material is exposed to incident electromagnetic radiation, energy is absorbed and the temperature of the material rises.

The resulting reduction in electron mobility manifests itself as a reduced electrical conductivity. If a bias current is already flowing through the strip then a reference potential is known and any change in conductivity causes a change in the reference potential which can be related to the amount of incident electromagnetic radiation. Depending on the rate of change in the material's electrical resistance with temperature and specifics of the bolometer design, temperature changes less than 0.0001 degC can be detected. To explore the effect of bolometer designs on detection of incident electromagnetic radiation, a computational model of a bolometer was developed using COMSOL Multiphysics® software.

Bolometer functionality is based on three main physical phenomena: radiation through the ambient environment, heat transfer within the solid parts and conservation of electric currents. The external radiation source originating from incident electromagnetic radiation associated with sunlight can be defined via the solar position in which the direction and intensity of the sun's incident radiation is based on the latitude and longitude position on the Earth, the date, and the time. Bolometer operation is modeled by coupling heat transfer and electric current.

Bolometers show greatest sensitivity when operating in a regime in which the absorbing strip material shows a strong dependence of conductivity to temperature. Depending on the material chosen for the absorbing strip, some bolometers may be more sensitive when operated at cryogenic temperatures.

Figures used in the abstract

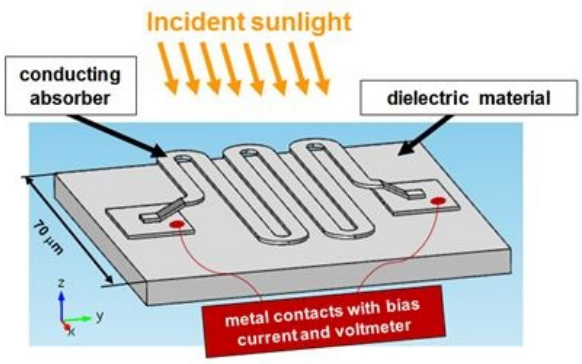

Figure 1: Figure 1: Bolometer model geometry and materials.

Figure 2

Figure 3

Figure 4