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Optimization of Thermopile Sensor Performance of Polycrystalline Silicon Film

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Abstract : A theoretical model for the optimization of thermopile sensor performance is developed for thermoelectric-based infrared radiation detection. It is shown that the performance of polycrystalline silicon film thermopile sensor can be optimized according to the thermoelectric quality factor, sensor layer structure factor, and sensor layout geometrical form factor. Based on the properties of electrons, phonons, grain boundaries, and their interactions, the thermoelectric quality factor of polycrystalline silicon is analyzed with the relaxation time approximation of the Boltzmann transport equation. The model includes the effect of grain structure, grain boundary trap properties, and doping concentration. The layer structure factor is analyzed with respect to the infrared absorption coefficient. The optimization of layout design is characterized by the form factor, which is calculated for different sensor designs. A double-layer polycrystalline silicon thermopile infrared sensor on a suspended membrane has been designed and fabricated with a CMOS-compatible process. The theoretical approach is confirmed by measurement results.

Keywords : polycrystalline silicon, relaxation time approximation, specific detectivity, thermal conductivity, thermopile infrared sensor
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