感温ガラス薄膜をもちいた赤外線検出器アレイ

Infrared Detector Array Using Temperature Sensitive Glass Thin Film

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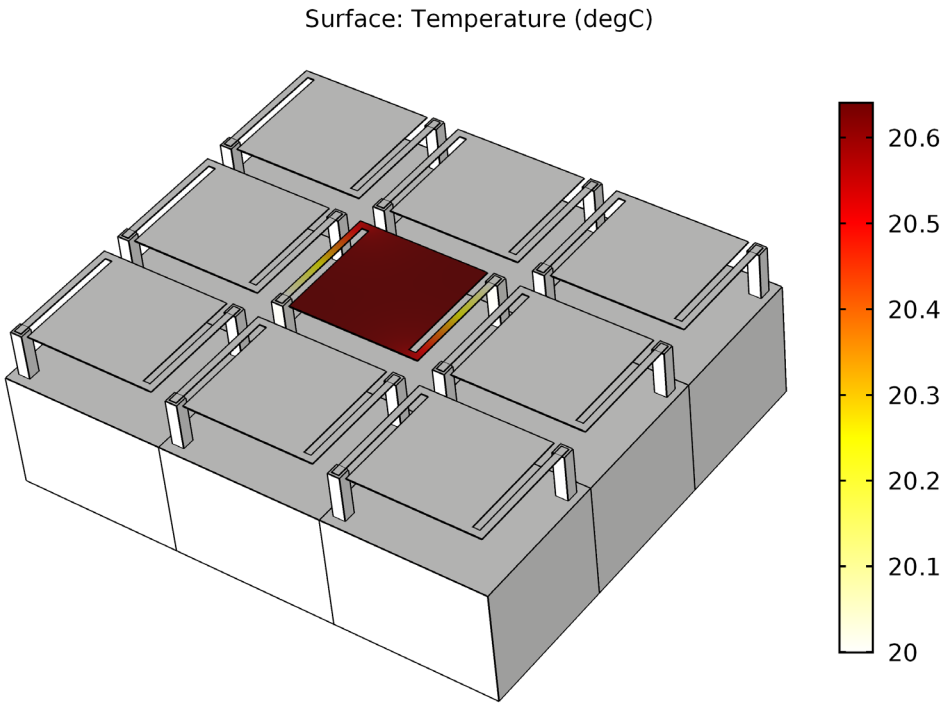
This study proposes a novel infrared-visible light conversion device with a simple structure to address the current limitations of infrared sensor arrays, which are widely used in applications such as non-contact temperature detection, night vision cameras, non-destructive testing, and gas detection. The proposed infrared detector consists of a temperature-sensitive thin film, a reflective film, and an infrared absorbing film, all supported by a low thermal conductivity thin film. The infrared radiation emitted by the target object is absorbed by the infrared absorbing film, converting it into temperature changes in each pixel. These temperature changes are read by the temperature-sensitive thin film, which utilizes the temperature-dependent intensity of light emission when exposed to excitation ultraviolet rays to convert the temperature distribution into an optical image. To enhance infrared detection sensitivity, two types of pixel structures were proposed and their thermal responses were verified using finite element analysis. The results showed that Design 1 exhibited a temperature rise of 0.6° C, while Design 2 exhibited a rise of 0.3° C, indicating that Design 1 was superior in sensitivity, while Design 2 was better in terms of pixel filling rate. Additionally, the thermal coupling between adjacent elements was negligible in both designs. Furthermore, a fabrication process to realize the designed detector was considered. Finally, a fabrication process incorporating anodic bonding, reactive ion etching, and the use of sol-gel glass materials was proposed. Inorganic glass was used as the base material for the temperature-sensitive thin film, requiring the establishment of a film formation technology using the sol-gel method. The optimal film formation conditions were explored by adjusting the mixing ratios of TEOS, water, and ethanol, as well as spin coating conditions.

This study aims to clarify these process conditions and complete the temperature-sensitive glass thin film, confirming the functionality of the proposed infrared imaging device through numerical simulations and detailed examinations of the fabrication process.

本研究では,赤外線センサアレイが非接触温度検出,暗視カメラ,非破壊検査,ガス検出などで広く利用されている現状に対し,簡易な構造で赤外線検出を可能にする未開発の赤外線ー可視光変換デバイスを提案し,感温ガラス材料の開発と加工方法を検討した.提案する赤外線検出器は,感温薄膜,反射膜,赤外吸収膜で構成され,熱伝導率の低い薄膜で支持されている.赤外線吸収膜が対象物からの赤外線を吸収し温度変化に変換し,この温度変化を感温薄膜で読み取る.感温薄膜は,励起紫外線照射による発光強度の温度依存性を利用して温度分布を光学画像に変換する.赤外線検出感度を高めるために,2 種類の画素構造を提案し,有限要素解析で熱応答を検証した結果,目標温度が 1 ℃の場合に, 設計 1 は 0.6℃,設計 2 は 0.3℃の温度上昇を示し,感度では設計 1 が優れており,画素の充填率では設計 2 が優れていた.また,隣接素子間の熱的結合も無視できる程度であることが確認された.さらに,設計した画素構造を実現するための作製プロセスを検討し, 陽極接合,反応性イオンエッチング,ゾルゲルガラス材料の使用などを含む作製プロセスを提案した.感温薄膜の母材として無機材料のガラスを使用しることを提案し,ゾルゲル法による成膜技術を検討した.TEOS,水,エタノールの混合比やスピンコーティング条件を調整して最適な成膜条件を模索中である.
本研究では,感温ガラスを用いた赤外線イメージング素子の構造と作製プロセスを提案し,数値シミュレーションにより機能性を確認し,感温ガラス薄膜の作製方法を検討し,そのプロセス条件を明らかにすることを目指している.



Surface: Temperature (degC)