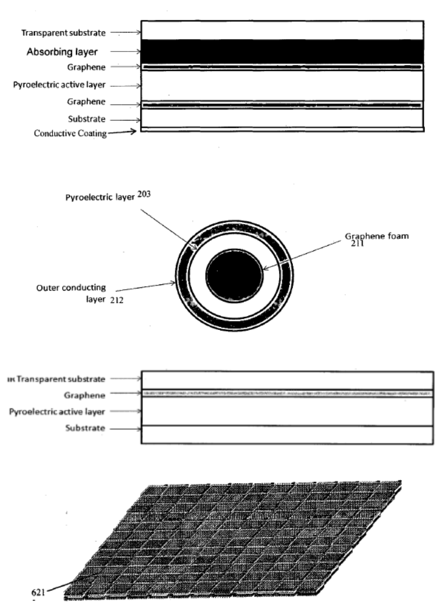
Joint Development Opportunity

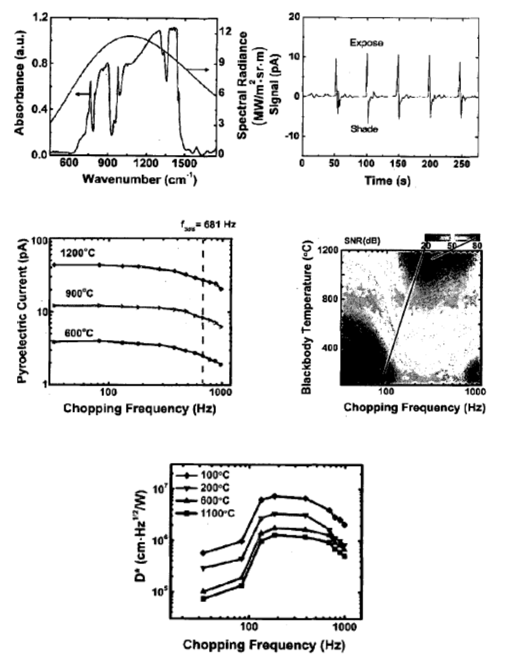
Tunable Pyroelectric Infrared Detectors using Graphene and Interconnected Graphene Foams

Types of Graphene-Pyroelectric Infrared Detectors



Array of pyroelectric sensors on pixelated sensing chip

Experimental results with Graphene-Pyroelectric IR Detectors



Technology Background

Infrared (IR) sensors are found in the industrial and research sectors, such as defence, quality control and inspection, surveillance, biomedical imaging and, in general, research and development. They rely on certain materials being able to capture variations in the infrared component of incident light. There are several problems with sensors in the market and this invention addresses the problems effectively.

Sensors in the market offer degraded performances in response time, sensitivity and high costs. High resolution *Mercury Cadmium Telluride (MCT) photoconductive IR detectors* have to operate at around 70 K. Although another type of sensor, *microbolometers*, can work at room temperature, they suffer from low resolution, compared to photoconductive detectors, a result of thermal cross-talk effects. Finally, *pyroelectric IR sensors*, utilizing IR-reflective top electrodes, have lower sensitivities compared to the first

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two types. This limitation is the direct result of the high reflectivity of the patterned top electrode. The often metallic surface of this electrode can also absorb IR, which also limits its tenability and flexibility.

Performance

Source	Drawback 1 (*Advantage*)	Drawback 2 (*Advantage*)	Drawback 3 (Advantage)	Experimental data
Bolometric IR detectors	A constant bias current needs to be passed through during operations	Accuracy is usually degraded due to thermal cross-talk	NA	NA
Photoconductive IR sensors	Materials used, e.g. mercury cadmium telluride and mercury zinc telluride are difficult to grow in controlled manner	Need for low operating temperatures	Need for a constant bias current	NA
Non-graphene Pyroelectric sensors	High reflectivity of the metallic top electrode reduces the effective flux of incident light	When specific IR-absorbing materials, e.g. NiCr alloys, are used, their predefined absorption spectra limit the wavelengths absorbed.	NA	NA
Graphene-pyroelectric IR sensor *(lab conditions)*	(*Significant improvement in detection rate, spatial and time resolution*)	(*High sensitivity, greater tunability, utilizing less power*)	(*Greater flexibility, compatible with pixelation*)	Highest signal @ blackbody temperature (1200 ^oC), chopping freq (33 Hz). Peak SNR: 75 dB at 1200 ^oC, 183 Hz. Specific detectivity$_{max}$: 7.42 x 10^6 cmHz$^{1/2}$/W @100^{o}C, 183 Hz

Application Areas

Low Cost spectrometer like multi-channel FTIR	Low Cost flexible sensors	Defense	Quality control and inspection	Biomedical and diagnosis	Surveillance and security	Research and development
Gas sensing, quality assurance systems, rapid substance identification for cross-border controls and military purposes	Gas sensing and identification, thermal and infrared sensors in textiles, watches and cellphones	Infrared sensors for night vision apparatus, onboard detectors for thermal tracking based missiles and weaponry, counteractive interception based systems for combustible propellant munition	Heat monitoring of circuit boards & components, mechanical metrology, i.e. monitoring of thermal degradation and structural defects in buildings, cars and other temperature sensitive applications	Differentiation or detection of malignancy in tissues, monitoring or detection of stress fractures, sensing of pandemics	Human motion detectors, low visibility (e.g. firefighting) apparatus, volcano surveillance	Photonic sensors in optical measurement devices

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