Article review on polymer infrared detectorandorganic and infrared sensor

Technology, Development

Polyvinylidene fluoride polymer first exhibited the piezoelectric effect in the year 1969 followed by the pyroelectric effect some years later, leading to the development of numerous applications of pyroelectricity and piezoelectricity. PVDF possesses many attractive features as a tactile or touch sensor. Tactile sensors can be used to monitor skin conditions. They find use in minimally invasive surgery. Tanaka et al. developed an active palpitation sensor to detect hypertrophy and prostate cancer. Pyroelectric and piezoelectric polymers help in energy conversion. The Energy Harvesting Eel device created by Taylor et al. used piezoelectric polymers for the conversion of mechanical flow energy of rivers and oceans to electrical power. Recent developments from cellular polymer include a soft piezoelectric transducer material which contains microscopic voids on the outer surface with negative and positive charges. Finland uses the material for commercial product development like keypads, keyboard push buttons and small push buttons. Hospitals and nursing homes utilize similar devices Additional applications include sports studies, hydrophones, orthopedic diagnostics, loudspeakers etc. Piezoelectric materials are common elements in stress gauges due to shock sensor properties. Photopyroelectric spectroscopy uses PVDF material for measurements of the properties of solids, gases and liquids. In recent times, commercially available uncooled IRFPA use ceramic pyroelectric material. The Dust Flux Monitor Instrument of NASA contains two PVDF sensors to detect comet particles.

The mid-infrared, commonly abbreviated as MIR, sensor has been developed based on the attenuated total reflectance. The analytical device helps locate various hydrocarbon compounds that remain dissolved in water. Under specific conditions, the MIR-ATR sensor can detect limits in the 10-100 ppb concentration range. As the infrared spectral aspects of ever molecule are unique, the sensor is rather selective and is capable of simultaneously distinguishing between several different analytes. Compared to other technological developments, the MIR-ATR sensor provides a much wider selectivity as the infrared spectrum is extremely characteristic of a certain substance. The cavities of the majority of polymeric materials being in the range of nanometer length, it is possible to sample only hydrophobic and small compounds. Even though several materials interact with hydrocarbons, only some achieve the level of ppb detection. Based on the membrane nature, the MIR sensor possesses the skill to simultaneously differentiate between several hydrocarbons belonging to the same family owing to their varying IR absorption spectra. The problem of biofouling has limited the long-term deployment of MIR-ATR sensor in aquatic surroundings. Different properties of the material can be altered to diminish the fouling problem. Nanotube matrix polymer-nanotube (CNT-P-CNT) and single walled carbon nanotube (SWCNT) junctions seem to have significant impact on the electro-optical features of SWCNT/polymer composites. Composite IR sensors developed from CoMoCAT-produced SWCNTs considerably outperform the sensors based on HiPco-produced SWCNT. The concentration of greater semiconducting nanotube in the material of SWCNT is crucial to improve the photo effect of the light of IR on carbon nanotube/polymer nanocomposites while CNT-P-CNT junctions have a major role in the thermal impact of IR light on supported SWCNT/polymer composite films. Single walled carbon nanotubes possess strong properties of absorption in the NIR region due to the first optical transition of the semi-conducting nanotubes. The tunneling resistance of CNT-P-CNT junctions promotes the electrical conductivity of carbon nanotube composites. The impact of CNT-P-CNT junctions on the electro-optical aspects of CNT/polymer remains unknown. The IR photoresponse in SWCNTs' electrical conductivity is enhanced dramatically by embedding the SWCNTs in insulating polymer matrix like polycarbonate (PC).

Temperature sensors can be used as infrared detectors. It is ideal to use an uncooled sensitive temperature sensor developed from a mechanical resonator, especially a commercially available tuning fork composed of quartz modified with polymer wire, since it will be cost effective. The polymer wire can help provide a temperature sensitive aspect to the actual tuning fork that is insensitive to temperature. Heating the polymer wire changes the stiffness of the wire, leading to changes in the effective spring consonant of the sensor of the tuning fork which in turn results in alteration of the resonant frequency. It is possible to improve and optimize the sensitivity of the infrared signal by choosing polymer materials that possess suitable thermal response. The application of infrared/temperature sensors is in the field of biological and chemical detection, since various species produce different response signatures over numerous infrared wavelengths. The microfabricated tuning fork temperature/infrared sensor possesses the sensibility, thermal response and stability to be used in different applications of infrared detection. Every tuning fork sensor needs to be modified on a manual basis and the wire thickness may vary depending on the individual calibration.

Wideband reflective polarizers have garnered a lot of attention in recent times due to their significance in practical applications. They have been prepared successfully from polymer network and chiral nematic liquid crystalline polymer composites. The (polymer network/ liquid crystal/ chiral dopant) composite has been prepared from photo-polymerization of (LC monomer of nematic diacrylate/ N-LC/ chiral dopant/ photoinitiator) mixture. Since the helical twisting power of the chiral dopant increases with the rise in temperature and the polymer network impacts the molecular rearrangement of the liquid crystals, the reflection spectrum of the composites has a bandwidth that becomes narrower and wider reversibly with decreasing and increasing temperature, respectively, making it suitable for thermally bandwidth-controllable reflective polarizers. It is possible to trace the location of the reflection band in the range of visible light or UV by increasing the amount of DC in the composite. The composite then possesses the prospects for a thermally sensitive visible or UV sensor.

Bottom gate organic thin-film transistors developed from high-k nanocomposite gate dielectrics and organic semiconductor pentacene showcase transistor performances with low voltage battery operation, low gate leakage currents, subthreshold swings near the theoretical limit. Organic thin-film transistors are normally used in the manufacture of cheap, flexible and disposable “ plastic” electronic products. Organic thin-film devices possess various properties such as low power consumption, lightweight, diverse substrates compatible and low operation voltage. It is important to reduce the subthreshold swing and the threshold voltage for the operation of organic thin-film transistors at low voltage levels. In combination with low gate leakage currents, organic thin-film transistors are an integral part of high-end sensor applications. The interface quality of different nanocomposite and organic gate dielectrics with pentacene leads to superior OTFTs that operate at low voltage, perfect for advanced sensor applications with low consumption of power. The transistor tools are assimilated with pyroelectric polymer sensors in transducer configuration and perform like a sensitive infrared detector and an optothermally activated switch.

Infrared (IR) sensors that employ optical readout stand for an innovative category of devices for thermographic imagery development. In a principle of infrared radiation detection based on one dimensional thermally tunable photonic crystals, performing the role of optical fibres, integrated with inorganic and organic light emitting diodes such as LEDs and OLEDs respectively, the optical fibers are manufactured using periodically assembled mesoporous SiO2 and TiO2 layers. The transmission spectrum of the optical fiber possesses thermal tunability that uses temperature to modulate the intensity of the light passing through the filter. The tuned spectrum lies in the visible region and so a visible-light photodetector is capable of directly detecting the spectrum. It is possible to resolve the local temperature profile time and spatially using a resolution of 530 by 530 pixel, thereby enabling a potential application in the form of infrared imaging sensor featuring low cost of fabrication as well as the minimal consumption of power.

Near Infrared (NIR) photo-responsive polyaniline-based conducting thin films can be created for the purpose of sensor application. Upon NIR illumination, the electrical conductance of the polyaniline thin films by improved by 5. 9%

and the response time was recorded as 20 seconds. The NIR sensing facility of polyaniline conducting polymer thin film can be compared to the bolometric carbon nanotube network devices. Polyaniline thin film NIR sensor can be manufactured by preparing the emeraldine base solution. The polyaniline thin films were first deposited on glass substrates through the process of spin-coating the EB solution. The films were then doped using aqueous 1 M HCl solution owing to the fact that the doped form of polyaniline emeraldine salt happens to be insoluble in accessible solvents. A layer of Au/Cr (100 nm/20 nm) electrodes with a gap of 50 μm was thermally evaporated on the polyaniline thin film. The development of a polyaniline thin film is possible to sense photons in the NIR area. The approach promotes the development of a polyaniline based NIR sensor array with low cost and the benefits of polymers over CNTs like economy, processability and productivity. The use of conducting polymer thin film is similar to NIR active material.

The property of infrared photoresponse in the electrical conductivity of SWNTs or single-walled carbon nanotubes has been dramatically improved through embedding single-walled carbon nanotubes in a thermally and electrically insulating polymer matrix. SWNTs have amazing optical and electronic properties, which provide the possibility of a unified optoelectronic and electronic technology. In case of individual single-walled carbon nanotubes or SWNT films, infrared photoresponse exists in the electrical conductivity. A nondamaging, versatile chemistry platform has been developed in recent times that allows the engineering of certain properties of carbon nanotube surface while preserving the intrinsic features of the carbon nanotube. The change in conductivity in a 5 wt % SWNT – polycarbonate nanocomposite happens to be sharp and considerable upon infrared illumination at room temperature in the air. Even though the thermal effect is the predominant feature in the infrared photoresponse of a pure SWNT film, in case of the infrared response of SWNT – polycarbonate nanocomposites, the photoeffect is predominant.

Pyrophilous species of insects, especially the flat bugs of the genus Aradus and beetles of the genus Melanophlia, have developed infrared receptors from common hair mechanoreceptors which allow them to detect hot surfaces and fires. Such insect infrared receptors are referred to as photomechanic. A photomechanic IR sensillum acts in the manner similar to microfluidic converter of IR radiation into expansion of internal pressure inside the outer exocuticular shell and the cavernous microfluidic core that acts as the sphere, which can be measured using a mechanosensitive neuron. Biometric infrared sensors can be developed based on the photomechanic IR receptors. The model features minor displacements of 1 nm or less in the sensing device. But the insects possess the advantage of an extremely sensitive mechanoreceptor which is capable of detecting small deflections in the membrance. The technical sensor is unable to achieve the sensitivity of the beetle. The former requires a suitable technical read-out mechanism possessing a high resolution of 1 nm. The displacement of the membrance can be enhanced by selecting liquids with optimal thermal properties and choosing the wall materials carefully.

Carbon nanotube, usually abbreviated as CNT, seems to be one of the best semiconducting materials for nanoelectric sensors owing to its exceptional electrical features. It is possible to develop an efficient spectrum sensor with the help of a single carbon nanotube. A steady and high-yield carbon nanotube band gap engineering must be used after development for the manufacture of a suitable carbon nanotube for the detection of infrared. The spectrum developed from carbon nanotube is able to sense successfully middle-wave IR and near IR signals at room temperature. The on-chip band gap engineering of the carbon nanotube exhibits that the desired band gap of a middle-wave carbon nanotube can be tuned with the help of the process of electrical breakdown. It is possible to adjust the sensitivity of the infrared sensor at certain wavelengths. The breakdown control method offers a high yield and steady on-chip band gap engineering approach which is perfect for adjusting the band structure of the carbon nanotubes. This step is necessary to produce the next generation of nano infrared sensors.

One of the most significant targets of the bio process engineering happens to be the real-time monitoring of crucial process variables. This forms the basis of exact process control and is necessary to gain high productivity along with the exact documentation of the entire process of production. Infrared spectroscopy seems to be a powerful analytical instrument that can be used to analyze an extensive range of organic compounds. Therefore, infrared sensors happen to be the ideal tools for monitoring of bioprocess. The sensors are non-invasive; there is no delay in time owing to sensor response times, and they have no direct influence on the bioprocess. Sampling is not necessary and it is possible to analyze numerous components at the same time. Usually it is seen that direct monitoring of products, substrates, metabolites along with the biomass itself is feasible. MIR spectroscopy and

NIR provide the chance of gaining a non-invasive, direct insight into the medium composition without any delay of time. Contemporary chemometric methods are vital for collecting valid data of the complex spectra but the spectroscopic monitoring method has potential.

The film of liquid crystal that remains suspended freely has properties that make it suitable for use as infrared and visible sensors of radiation. In a Golay cell, the polymer film might be replaced by a film of liquid crystal that leads to the effective increase of the response rate of the sensor without any setback in its sensitivity property. Films in the Golay cell that remain freely suspended can be used in the detection of visible and infrared radiation. The liquid crystal film which is suspended freely can be applied as the sensitive element of the optical microphone present in the Golay cell considerably increases the detector's response rate. A greater rate of operation of the detector will prove to be useful for the discrimination of noise with low frequency that possesses well-known dependence on inverse frequency. Every Golay cell seems to be equipped with a freely suspended film that is robust enough and is capable of withstanding moderate levels of mechanical shock without the risk of degradation of performance.

Pyroelectric detectors are considered to be the fast thermal detectors since variations in temperature at the molecular level are directly involved in the process of detection. The pyroelectric properties of PVDF come in handy in infrared detectors. But the sensitivity of PVDF is not very high and in order to overcome the issue the best option is to integrate the sensor with the readout electronics. Gluing the PVDF sheet to silicon substrate solves the issue of the thin material. In recent times, PVDF is used in combination with silicon integrated circuits. Two infrared sensors can be set up using PVDF. In the first case, a PVDF membrane was mounted on a support ring and the signal which was generated pyroelectrically was read out with the help of a charge amplifier. Another setup uses a MOSFET to read out the signal of PVDF foil attached to silicon substrate. The infrared input power is similar to the output signal in both setups. In both cases, the electrical transfer properties have the same features. The main difference is present in thermal parameters. Better thermal isolation leads to higher sensitivity in lower frequencies. The sensor using PVDF glued to silicon substrate containing the MOSFET readout circuitry can operate across different frequencies. A mixture of the MOSFET readout principle ideal for matrix design with improved thermal isolation leads to an optimal design for the integrated sensor.