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METHOD AND APPARATUS FOR BIAS AND READOUT OF BOLOMETERS OPERATED ON A HYSTERETIC METAL-INSULATOR TRANSITION

High speed, sensitive microbolometer for IR applications

Description

Microbolometers are useful in the detection and measurement of infrared (IR) radiation and other forms of electromagnetic power. This design of a microbolometer takes advantage of the sensitive, sharp phase transition displayed by a number of uncooled bolometer materials (metal semiconductors), for example vanadium oxide. Usually the transition in these materials is hysteretic, meaning that the detection temperature changes depending on whether the material is heated up or cooled down to the transition state. This microbolometer design avoids such hysteretic behaviors by applying an alternating current or change in voltage across the semiconducting material, amplifying the change in temperature caused by the signal. During each cycle, the current heats the material completely into the conducting state. The voltage, which is highly sensitive to incident IR loading, is sampled as the material cools into the transition region. This technique permits the use of metal semiconductors which work at high speed, low noise, and are resistant to ambient temperature fluctuations.

Applications

- **Thermal imaging**
  Used in night vision systems for security and surveillance; search and rescue; firefighting and law enforcement; remote (non-contact) thermal imaging for manufacturing process control; rapid thermal processing of semiconductors; remote (non-contact) thermal imaging for failure recognition in machinery; non-destructive inspection and testing; pollution monitoring; and power distribution inspection

Advantages

- **Wide range of bolometer characteristics**
  This technique uses metal-semiconductors having the advantages of higher speed, lower noise, and great immunity to ambient temperature fluctuations
- **Operates with extreme electrothermal feedback**
  The accessibility of the full slope of the R(T) characteristic, enables the bolometer to perform in the extreme electrothermal feedback regime, which creates drastic improvements in speed, 1/f-noise, and sensitivity

Abstract

This invention consists of a bias and readout scheme for resistive bolometers. It is chiefly intended for use with bolometer materials which exhibit a phase transition that is hysteretic. A preferred bolometer material is vanadium dioxide, which has a metal-semiconductor phase transition at 68° C. and a hysteresis of typically 5° C., depending on material preparation. The existence of hysteresis precludes the use of a conventional dc bias or a conventional pulsed bias in a bolometer operated on the phase transition. In the present method, the bias consists of an ac current for phase transitions in which the resistance decreases with increasing temperature. For phase transitions in which the resistance increases with temperature, an ac voltage bias would be used.) The waveform of the ac bias consists of a short "reset" segment in which the peak current is high enough to bring the bolometer completely into its metallic state, followed by a longer "data" segment in which the bias current and bias power monotonically decrease, so as to sweep the bolometer's physical temperature downward across the phase transition. The frequency of the ac bias is determined by the condition that the slew rate in bias power during the data segment must always exceed the slew rate in signal power, for all signals of interest. The signal is read out by averaging the bolometer voltage over a time window lying entirely within the data segment. With this bias and readout scheme, the full slope of the bolometer R(T) characteristic is reflected in the output from small signals, which would not be the case for a conventional dc or pulsed bias scheme. Since the full slope of the R(T) characteristic is accessible, the bolometer can operate in the extreme electrothermal feedback regime, which provides major improvements in speed, 1/f-noise, and sensitivity.

Inventors

- Grossman, Erich N.
- Reintsema, Carl D.

Related Items

- Article: Heat Measurements

References

- U.S. Patent #6,323,486 issued 11-27-2001, expires 07/30/2019
- Docket: 98-029US

Status of Availability

active patent and available for licensing

Last Modified: 12/28/2010