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High sensitivity 80x64 Thermopile infrared array sensors

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Abstract

Heimann Sensor introduced in 2016 the first monolithic 80x64 thermopile array sensor. Since the market shows an increased demand of low cost infrared sensing solutions with improved performance Heimann presents an update of the 80x64d in this year.

Key words: Thermopile array, 80x64 pixels, infrared detection, true shutterless, medium resolution

Introduction

Since the introduction of the first fully monolithic thermopile array Heimann Sensor consequently broadens its array portfolio [1].

Already in 2016 Heimann introduced the first digital 80x64 arrays [2]. In recent years the first array types were completed to a full family of digital thermopile arrays from 8x8, 16x4, 16x16, 32x32 and 80x64.

Since thermopile solutions are very insensitive against environment changes (such as ambient temperature) it is not necessary to use offset correcting measures, such as shutters and / or thermal stabilizers such as TECs. Also the sensitivity has a very low temperature coefficient (TC), which can be considered in calibration without any further effort, The competitive extended object temperature measurement range allows not only usage in the “classic” infrared imaging applications such as hand held thermal imagers, security cameras remote temperature measurement, it in fact enables also usage in industrial process control for very high temperatures and hotspot detection. The competitive price of the thermopile arrays also allows entrance to the high volume markets such as HVAC, person detection, energy management and automotive.

The low power consumption of these systems renders also battery powered applications possible. The arrays are further offered with a wide range of optics to adapt to various applications and additional measures to increase sensitivity and fill factor.

Functional description of the digital thermopile array sensors

The 80x64 sensor has several internal amplifiers (OPA) for signal conditioning and Analog to Digital Converters (ADC) with a resolution of 16 bit for digitizing.

In addition two proportional to ambient temperature circuits (Vtemp) are placed on the chip to measure the ambient temperature. The architecture of the 80x64 array chip was described in [2].

Readout of the 80x64 sensor

Thanks to the internal 16 bit ADC and an integrated EEPROM inside the TO package with optics, the complete array can be provided as fully calibrated array with a six pin package. The calibration data and the pixel data stream can be read via the integrated serial peripheral interface (SPI).

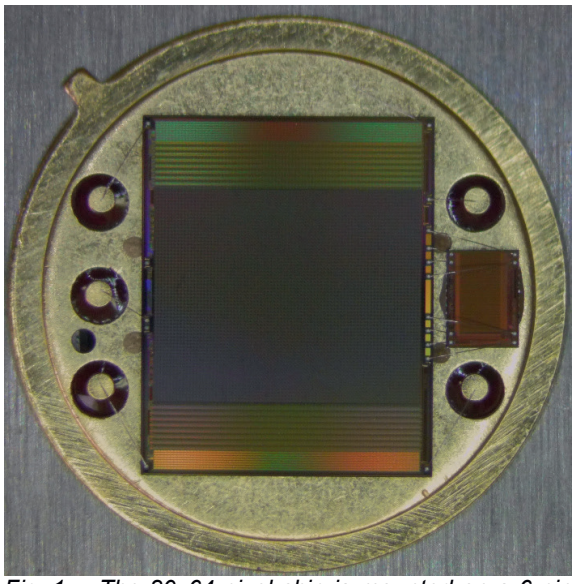


Fig. 1. The 80x64 pixel chip is mounted on a 6 pin TO8 header together with an EEPROM chip. The optics is mounted inside the TO cap.

Since the signal from the pixel decreases with smaller pixel sizes, there are different options to maintain a good signal to noise ratio (SNR):

- The use of a special chip design with thermally isolated membrane from the Si heat sink by thin beams
- Reducing the heat conductivity of the gas around the pixel and
- Enhancing the fill factor by additional absorber structures (so called umbrellas!)

Fig. 2 a) shows a thermopile array pixel with a thin reticulated membrane 4, which is suspended on two beams 3 between the Si frame (substrate) 2. The beams 3 are carrying the thermoelectric sensitive materials n- and p-type Poly-Si as thermocouples. They are isolated by slots 7 from the membrane. The Si frame is also acting as a heat sink. The hot junctions 9 are located on the suspended membrane and the cold junctions 8 are at the heat sink. The membrane is covered by an IR absorbing layer 4.

In Fig. 2 b) such array pixel is depicted as cross sectional view. For enhanced signal the fill factor can be increased by adding an umbrella type radiation collector. In Fig. 2 c), the much bigger absorbing area of the umbrella compared to the area of the absorber on the membrane only is clearly shown.

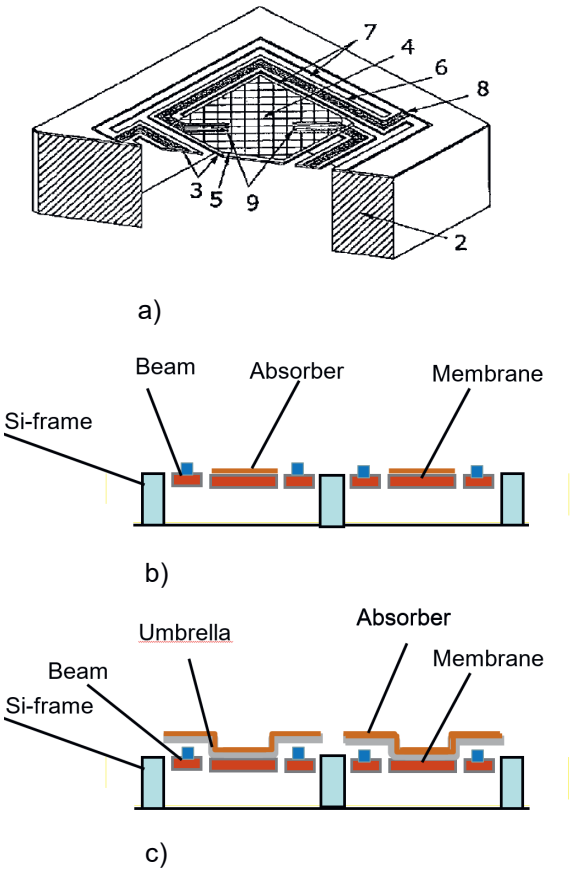


Fig. 2. Thermopile array pixel with reticulated membrane, suspended on thin beams, a) in a 3D view, b) as cross sectional view with a normal absorber on the membrane and c) with additional umbrella type radiation collector covered with additional absorber layer.

The realization of thermopile pixels with absorber layer can be seen in Fig. 3:

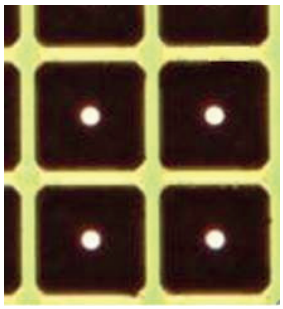
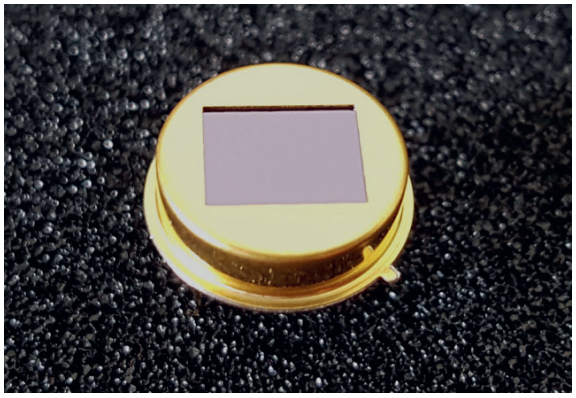


Fig 3.: Thermopile array pixels covered by umbrella and absorber.

The array chip is mounted onto a TO-8 header inside a metal can, which is hermetically sealed to maintain a Xe atmosphere. Xe is used due to its about 4.5 x lower heat conductivity compared to air or N2.

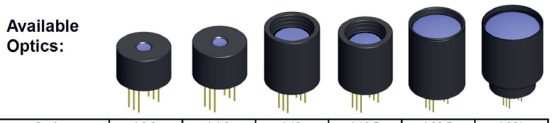
A further signal improvement can be reached by sealing the TO-8 can under vacuum atmosphere). For that purpose we soldered the

lens or entrance filter to the metal can for reaching stable hermeticity.



Optical design of the 80x64 sensor

There are currently 6 different optics designed and available for this sensor. The field of view (FoV), the F-number and optics dimensions are listed in Fig. 4.



Optic	L3.9	L4.8	L10	L10.5	L22.5	L33*
FoV [°]	115 x 90	90 x 72	41 x 33	39 x 31	18 x 14	12 x 9
Length of cap [mm]	12.6	14.4	25.7	24.1	36.5	46
Diameter of cap [mm]	20	20	23	23	28	37
F-number	0.8	0.8	0.7	0.95	1.0	1.05

Fig. 4. The sensor equipped with different optics.

Unlike the smaller arrays (8x8, 16x16 and most 32x32), where a single lens optics is sufficient, for 80x64 arrays two lens optics are necessary for good optical performance.
While the 80x64 thermopile array is in mass production, we are planning for an 120x84 array. Thanks to smaller pitch of 60 µm, the chip size is similar to the 80x64, so that also the 120x84 fits in same TO-8 housing as the 80x64.

Measurement results and settings

The frame rate can be chosen up to 22 Hz with the full 16 bit resolution and can achieve >100 Hz for a lower ADC resolution.

Maximum possible frame rate is reached with an SPI-clock of 20 MHz for the full readout of the sensor

The NETD of a vacuum packaged 80x64d array can reach 19 mK@1Hz@25°C with the latest Pixel design and the best optics.

NETD values reach 150….300 mK for the standard version depending on optics.

Special optics allow to measure temperatures up to 1000 °C and above.

In the following Figures we show thermal images taken with our application set using the highest resolution thermopile arrays with vacuum sealing:

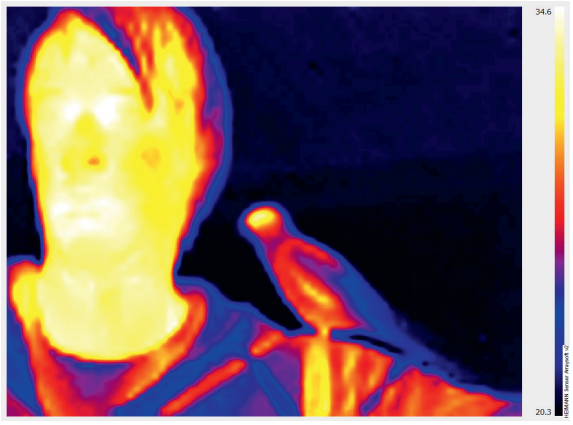


Fig. 5. Thermal image with 80x64d array showing a bird sitting on a human´s shoulder.

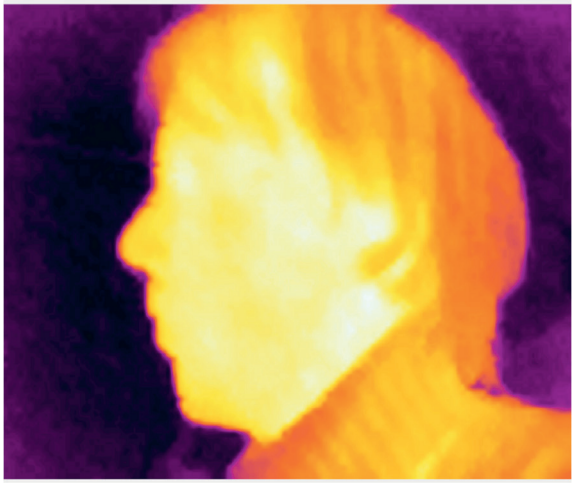
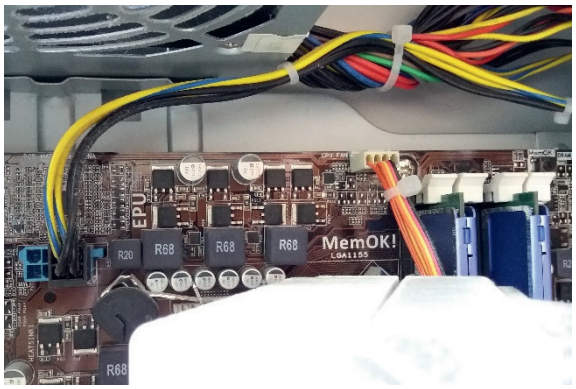
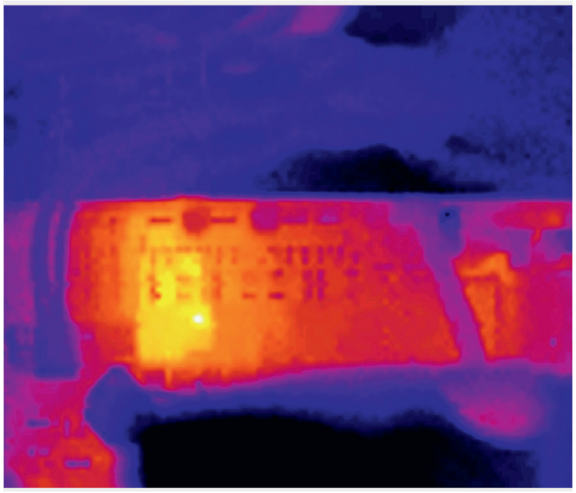


Fig. 6. Another thermal image showing a person from the side.



7 a)



7 b)

7 c)

Fig. 7. Thermal images of a CPU showing hot spots, saved with different color scalings: a) visual image, b) false color thermal image and c) black and white thermal image.

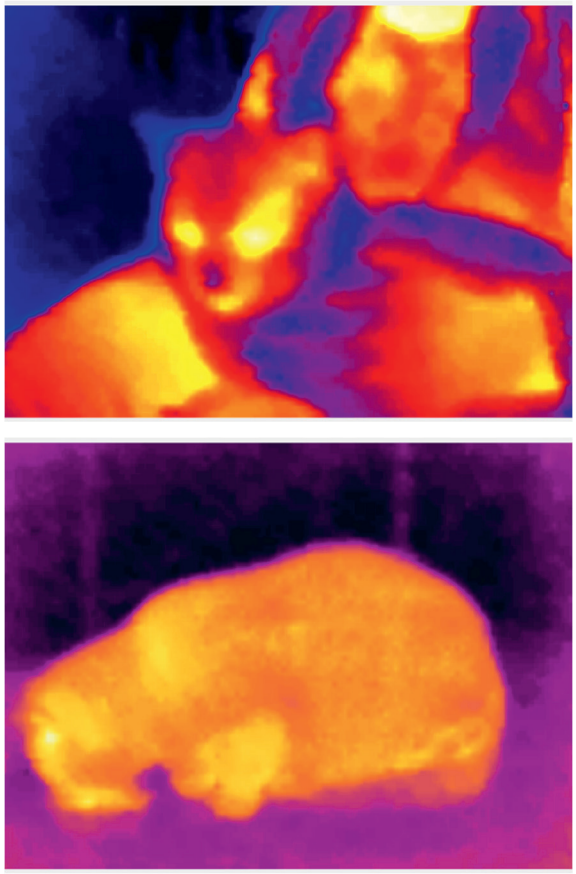


Fig. 8. Thermal images of a cat sitting on a person and eating on the floor.

Application set

For customer´s application support we developed a further improved application set allowing thermal imaging direct to any connected PC. The new software allows to show simultaneously the thermal videos of up to 8 IR modules in parallel on a PC or larger screen.

References

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