Novel Low-Cost Approach for Low to Mid-Resolution Un-cooled Thermosensor Arrays Based on MEMS Pressure Sensor Process

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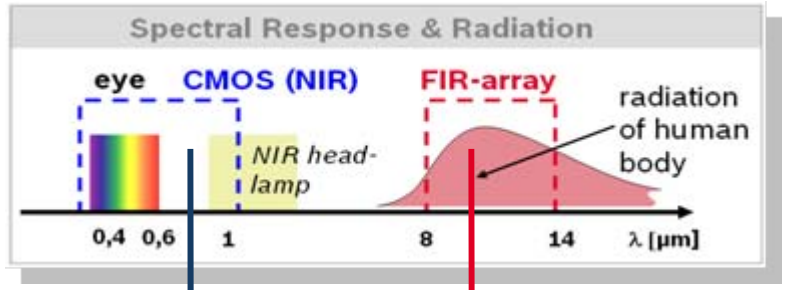
- Motivation/Background
- Application Scenario
- Low-cost Approach
- Progress/Status
- Outlook

Motivation/Background

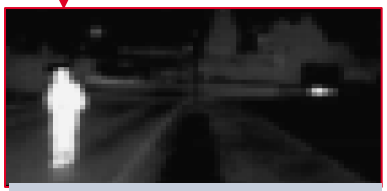
- Current automotive night vision systems are too expensive to be integrated in cars below the upper and luxury class
  - NIR based systems need costly NIR-headlights
  - NIR systems give a more "natural" image, but have difficulties in detecting living objects
  - FIR based systems with 320x240 pixels are expensive
  - FIR systems may display irritating details especially at daylight and additional features like road sign or lane recognition are harder to implement

- Possible solution: "Poor man's nightvision"
  - VIS/NIR CMOS without costly NIR-headlights for basic object recognition (signs, lane boundary, other cars, etc.)
  - Low-cost FIR system for hot-spot detection

"Poor Man's Night Vision"



NIR-CMOS: Good image quality



Low-cost FIR: Hot spot detection

Fusion for reliable warning system

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Application Scenario ADOSE (FIR-add-on part)

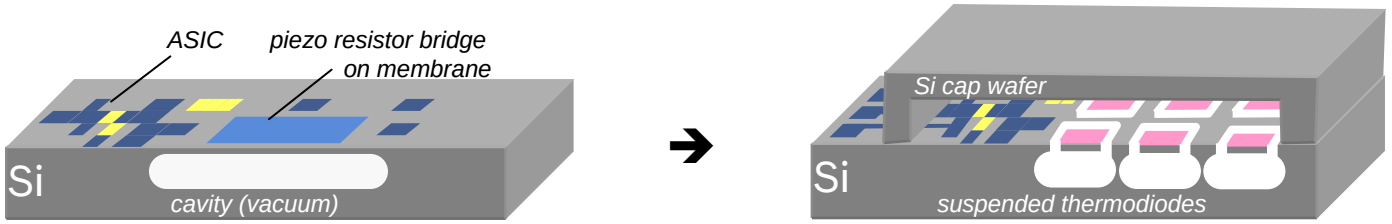
- Collision avoidance on extra-urban roads
  - Function: Collision warning
  - Object size > 0.5m x 1.0m
  - Speed: 50km/h < v < 100km/h
  - Environment:
    - All lighting conditions
    - All weather conditions
    - All road types except urban and motorways

Requirement:		Comment
Wavelength range:	7 – 14 µm	emission optimum
Field of view (FOV):	± 12°	adapted to NIR
Angular resolution:	0.24 ° / pixel	defined by hot spot resolution
Pixels:	100 (h) x 50 (v)	
Thermal resolution:	< 0.5 K	hot spot, no grey-scale image NETD < 300mK @ f/1.0
Frame Rate:	min. 12.5 Hz	25 Hz readout
Operating temperature:	-40° .. +80°C	

- Expected restrictions for passive infrared system
  - No secure detection of "cold" objects
  - Reduced performance in heavy rain, spindrift, fog
  - Reduced performance in warm environmental conditions
  - Slow reaction time (compared to active NIR system)

Low-cost Approach

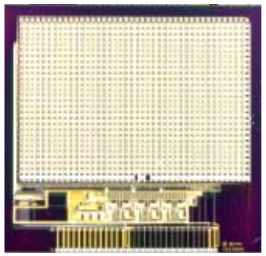
- Key to low-cost imager production lies in economies of scale by using process technology of existing mass-production sensors
- BOSCH MEMS process for integrated pressure sensors together with wafer-level packaging used widely in inertia sensors provide the technological base
- Use of forward-current biased diodes in monocrystalline silicon as low-noise thermal sensors
  - Available in process without need of additional material
  - Enables lateral ROIC integration through self-decoupling matrix
  - Reduced self-heating issue
- Use of bulk absorption in process inherent oxide layers



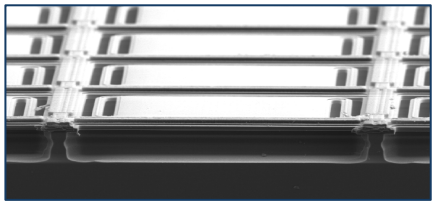
Pressure sensor → FIR imager

Progress/Status (1)

- Proof-of-concept demonstrators with 230µm pixel pitch and 28 by 42 pixels with integrated analog evaluation circuit and waferlevel vacuum package have been produced and characterized successfully, NETD(F#1, 30°C, 1Hz) of 0.4K was achieved

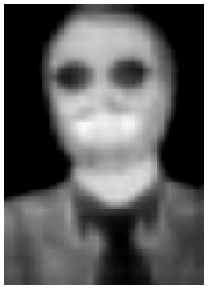


<- Chip image,
ROIC below array

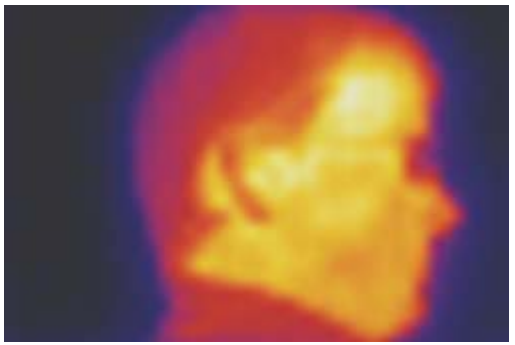


<- Cross section side view
of thermal sensor element

<- native resolution 28x42
3x bicubic interpolated ->



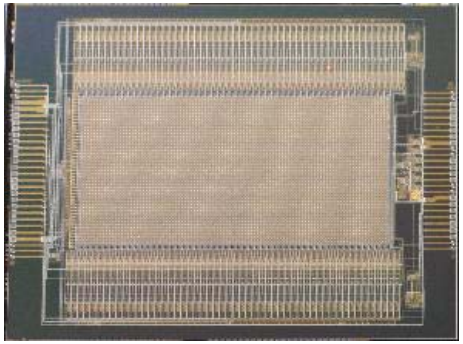
False color image with ->
6x bicubic interpolation

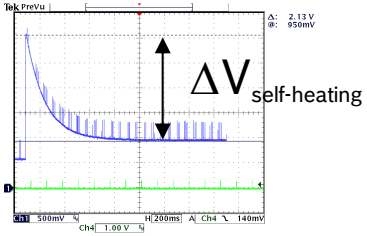


Progress/Status (2)

- ADOSE spec arrays with 100µm pixel pitch and 100 by 50 pixels were produced successfully
- Responsivity measurements show pixels meet design targets
- Target NETD not yet achieved due to ROIC crosstalk problems
- FIR Arrays with optimized ROIC available Q2/2011.

Image of first ADOSE silicon. -> ROIC distributed to top and bottom side of array





<- Responsivity measurement through self-heating of pixels

Outlook

- ADOSE extended till 09/2011. Remaining activities:
- Evaluation of 100 x 50 demonstrator after metal-fix
  - Completion of demonstrator camera, characterization and validation of results
  - Implementation of demonstrator in test car together with other ADOSE sensors by ADOSE partners

- IR activities @RB are continued in Spitzencluster MicrotecSW project RTFIR:
  - Evolve technology to achieve 25µm pixel pitch and 320x240 pixels
  - New ROIC concept to improve scalability
  - New WLP technology to reduce chip size

Thank you for your attention!

Any questions?