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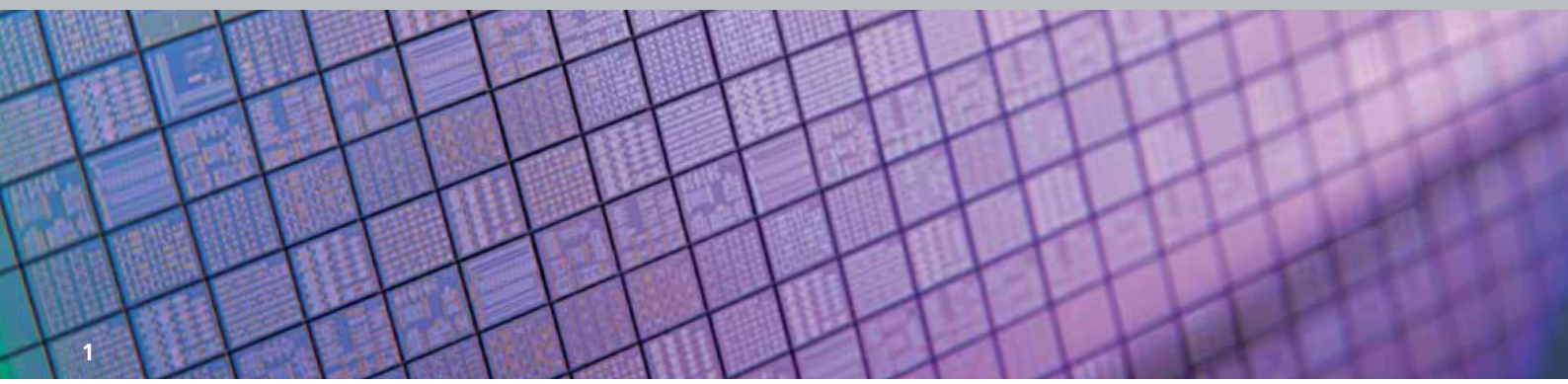

1 *Logic circuits (flip-flops, inverters, oscillators, and more) implemented in 4H-SiC operabele at high temperatures*

4H-SiC HIGH TEMPERATURE SENSING & ELECTRONICS

SENSORS, SIGNAL PROCESSING AND ACTUATORS OPERABLE UP TO 600 °C

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General Description

- Mixed-signal circuits operating at temperatures beyond 250 °C
- Combination of sensing function with on-chip amplification and Smart-Power IC for actuation

Features

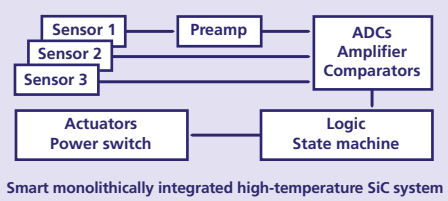
- Wide range of applications:
  - Temperature
  - UV emission
  - Particles and radiation
  - Magnetic field
  - Chemical compounds
  - Pressure
- Operating temperatures up to 600 °C
- Amplification circuits and logic
- Acutators like HV switches

Advantages

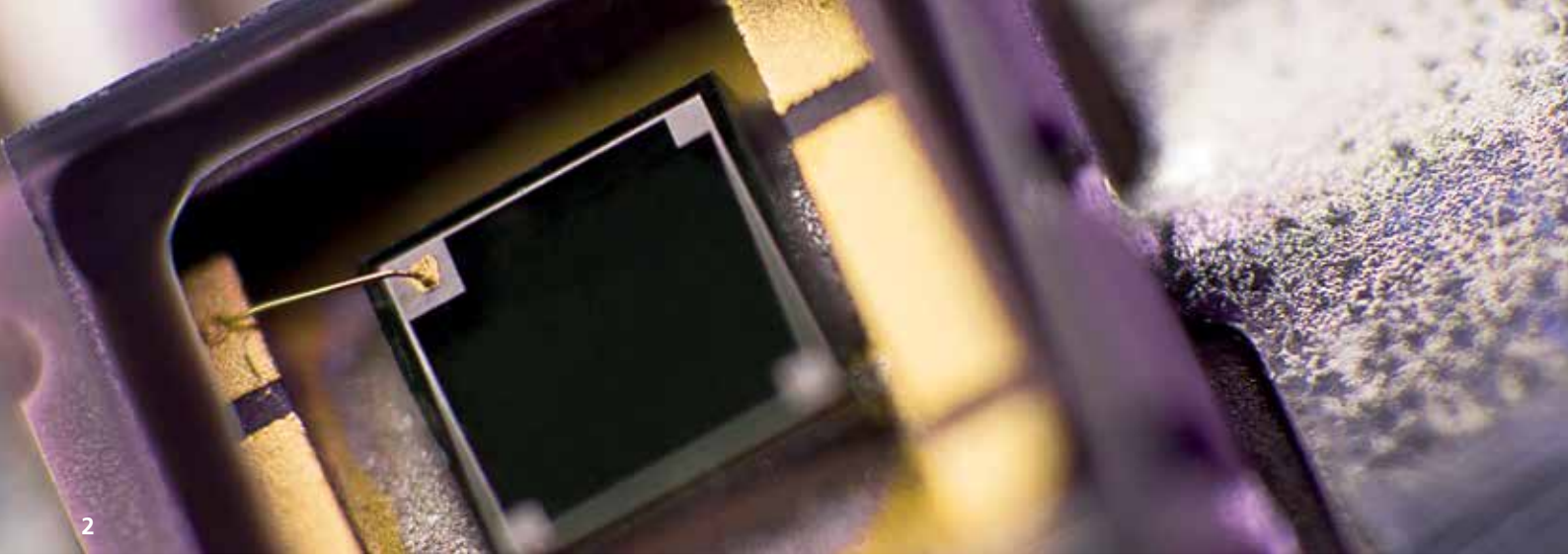
- Higher thermal stability than Si
- Robust to harsh environments
- Compact single chip solution

Benefits

- Less effort for sensor maintainance (stability)
- Cost reduction by monolithic integration
- Best-in-class high temperature performance of semiconductor-based sensors



Smart monolithically integrated high-temperature SiC system



Sensor Functions

Temperature

- Temperature-sensitive diodes operating in constant current forward bias mode (CCFB)
  - – High sensitivity (dV/dT): up to 4.5 mV/K
  - – High linearity up to 500 °C

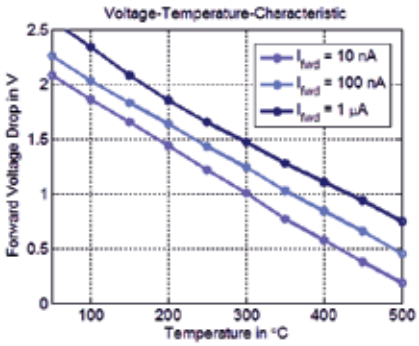


Fig. 1: V-T-characteristic of a 1.3 x 1.3 mm² temperature sensor in CCFB mode

- PTAT circuits
  - – Sensitivity: 0.2 mV/K
  - – Tunable (area and current ratio)
  - – Sat. current independent

UV emission

- Tunable responsivity
- Maximum at 260 nm: 110 mA/W
- Near-constant responsitivity from 270-300 nm
- Typical maximal external quantum efficiency of 55%
- Sensor arrays

Fast particles and radiation

- Soft x-ray detection
- Neutron detection

Pressure

- Piezo resistivity
- Capacitance 3.9 mV/bar at 300 °C

Magnetic fields

- Hall effect based Magnetic FETs

Chemical Compounds

- ISFET mode for detection of distinct elements and compounds

Signal Processing

Analog electronic circuits

- Amplifier
- Comparators
- Current mirrors

Electronic sensing and actuation circuits

- ADCs
- pre-Amps

Digital electronic circuits

- Inverters, Flip-flops
- State-machines
- Technology Details
  - – High-temperature CMOS
  - – μ_{NMOS}/μ_{PMOS} = 3.8 @ 300 °C

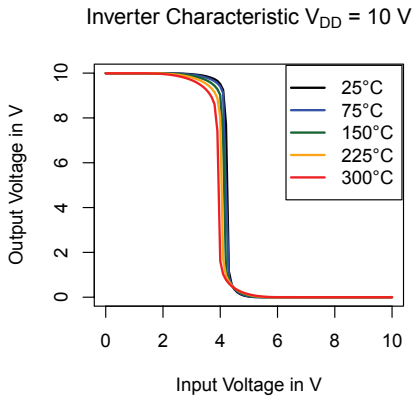


Fig. 2: Transfer characteristic of a 4H-SiC CMOS inverter at different temperatures

Actuation

- High voltage devices
  - – LDMOS transistors based on pin or RESURF
  - – High-side capability by well-isolation
- Excellent Power-FOM at 600 V compared to silicon
- On-state resistance < 10 mΩ cm² @ 650V

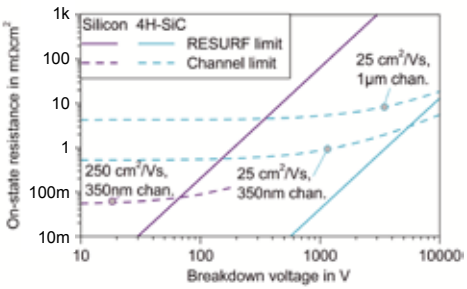


Fig. 3: On-state resistance as a function of the breakdown voltage of 4H-SiC HV-switches exceeding the silicon limit