

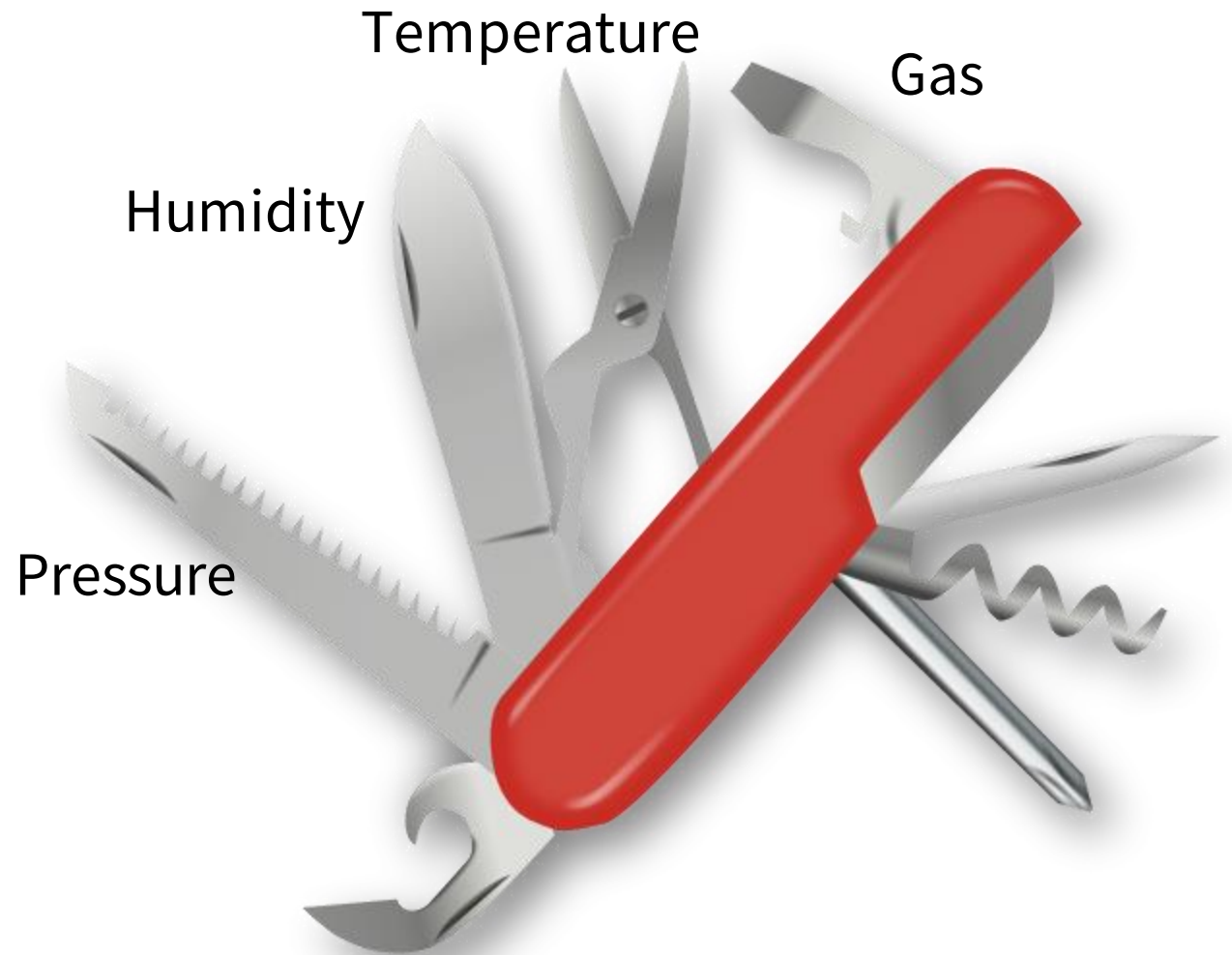
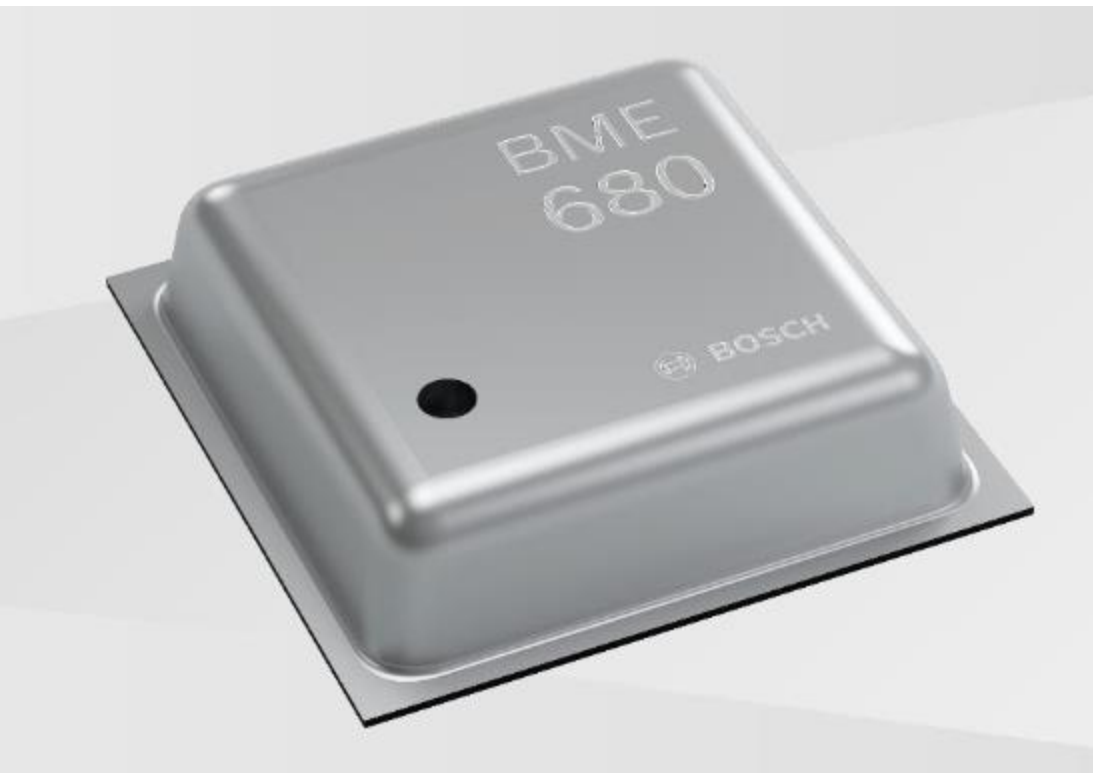
# Atmospheric Sensors: BME680

Ivan Velkovsky

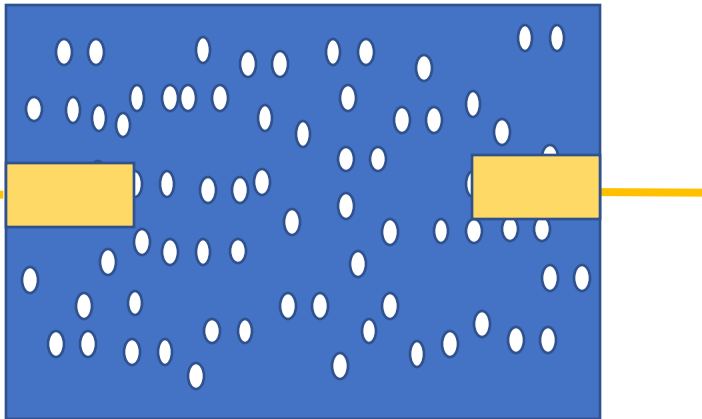
# Mini-lecture outline:

- BME680 and its many uses
  - Quick physics overview
  - How to use it
  - Datasheet skills – identifying relevant information

# BME680 – the atmospheric Swiss army knife



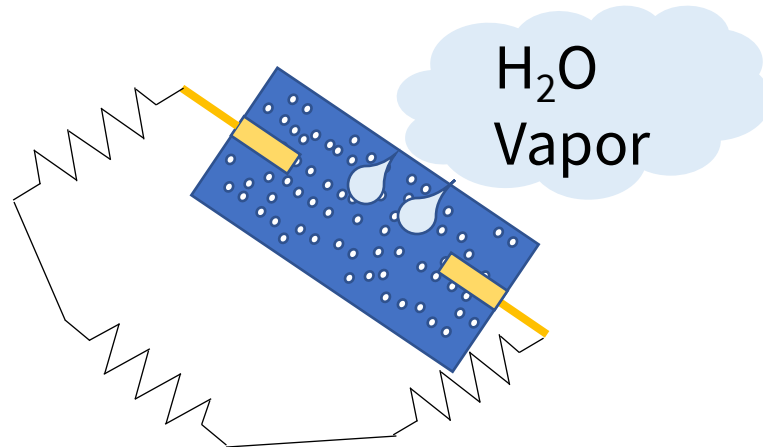
# Pressure and temperature: Porous Silicon Membrane



- Sensor is a porous membrane in an internal cavity
- Porous silicon is *piezoresistive* – resistivity changes with strain
- 2 different sources of strain: temperature variation (differences in thermal expansion of different materials) and pressure change.
- Device converts change in resistivity to change in temperature and pressure

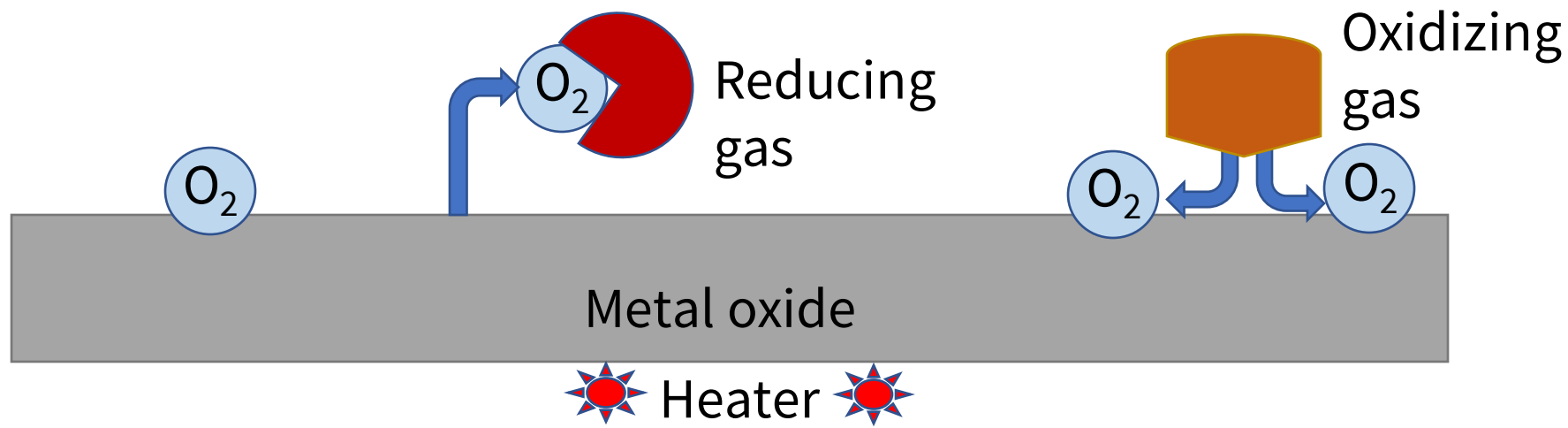
# Relative humidity – you guessed it, porous silicon!

- Same membrane technology can be used to measure relative humidity
- Water adsorption onto a specially-designed surface changes the capacitance/resistivity of the device
- Measuring that gives the % relative humidity.



# Something slightly different – VOCs & Metal-Oxide gas sensors

- VOC – volatile organic compound, harmful for air quality (ex: solvent fumes)
- Metal oxide adsorbs oxygen molecules to its surface when heated, reducing electron mobility -> increasing resistivity
- Reducing/oxidizing gases change surface oxygen level
- Change in resistivity thus gives gas concentration.



# Datasheet info:

- <https://www.bosch-sensortec.com/media/boschsensortec/downloads/datasheets/bst-bme680-ds001.pdf>

## 1.5 Temperature sensor specification

Table 8: Temperature parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating temperature range	$T_A$	operational	-40	25	85	°C
Supply current	$I_{DD,T}$	1 Hz forced mode, temperature measurement only		1.0		μA
Absolute accuracy temperature <sup>15</sup>	$A_{T,25}$	25 °C		±0.5		°C
	$A_{T,full}$	0–65 °C		±1.0		°C
Output resolution	$R_T$	API output resolution		0.01		°C
RMS noise	$N_T$	Lowest oversampling		0.005		°C



## 1.4 Pressure sensor specification

Table 7: Pressure parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating temperature range	T <sub>A</sub>	operational	-40	25	85	°C
		full accuracy	0		65	
Operating pressure range	P	full accuracy	300		1100	hPa
Supply current	I <sub>DD,LP</sub>	1 Hz forced mode, pressure and temperature, lowest power		3.1	4.2	μA
Temperature coefficient of offset <sup>13</sup>	TCO <sub>P</sub>	25–40 °C, 900 hPa		±1.3		Pa/K
				±10.9		cm/K
Absolute accuracy pressure	A <sub>p, full</sub>	300–1100 hPa 0–65°C		±0.6		hPa
Relative accuracy pressure	A <sub>rel</sub>	700–900hPa, 25–40 °C, at constant humidity		±0.12		hPa
	A <sub>rel</sub>	900–1100hPa 25–40 °C, at constant humidity		±0.12		hPa
Resolution of pressure output data	R <sub>P</sub>	Highest oversampling		0.18		Pa
Noise in pressure	N <sub>P,fullBW</sub>	Full bandwidth, highest oversampling		1.4		Pa
				11		cm
		Reduced bandwidth, highest oversampling		0.2		Pa
				1.7		cm
Solder drift		Minimum solder height 50μm	-0.5	1.2	+2.0	hPa
Long-term stability <sup>14</sup>	P <sub>stab</sub>	per year		±1.0		hPa
Possible sampling rate	f <sub>sample_P</sub>	Lowest oversampling, see chapter 3.3.2	157	182		Hz

## 1.3 Humidity sensor specification

Table 6: Humidity parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating Range <sup>10</sup>			-40	25	85	°C
			0		100	% r.H.
Full accuracy range			0		65	°C
			10		90	% r.H.
Supply Current	$I_{DD,H}$	1 Hz forced mode, temperature and humidity measurement		2.1	2.8	μA
Absolute Accuracy	$A_H$	20–80 % r.H., 25 °C, including hysteresis		±3		% r.H.
Hysteresis <sup>11</sup>	$H_H$	10→90→10 % r.H., 25°C		±1.5		% r.H.
Nonlinearity	$NL_H$	10→90 % r.H., 25°C		1.7		% r.H.
Response time to complete 63% of step <sup>12</sup>	$\tau_{0.63\%}$	N <sub>2</sub> (dry) → 90 % r.H., 25°C		8		s
Resolution	$R_H$			0.008		% r.H.
Noise in humidity (RMS)	$N_H$	Highest oversampling		0.01		% r.H.
Long-term stability	$\Delta H_{stab}$	10–90 % r.H., 25°C		0.5		% r.H./ year

Table 2: Gas sensor parameter specification

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operational range <sup>1</sup>			-40		85	°C
			10		95	% r.H.
Supply Current during heater operation	I <sub>DD</sub>	Heater target temperature 320 °C, constant operation (V <sub>DD</sub> ≤ 1.8 V, 25°C)	9	12	13	mA
Peak Supply Current	I <sub>Peak</sub>	Occurs within first ms of switching on the hotplate	15	17	18	mA
Average Supply Current (V <sub>DD</sub> ≤ 1.8 V, 25°C)	I <sub>DD,IAQ</sub>	Ultra-low power mode		0.09		mA
		Low power mode		0.9		mA
		Continuous mode		12		mA
Response time <sup>2</sup> (brand-new sensors)	τ <sub>33-63%</sub>	Ultra-low power mode		92		s
	τ <sub>33-63%</sub>	Low power mode		1.4		s
	τ <sub>33-63%</sub>	Continuous mode		0.75		s
Resolution of gas sensor resistance measurement			0.05	0.08	0.11	%
Noise in gas sensor resistance (RMS)	N <sub>R</sub>			1.5		%