
NANOZ
Hydrogen & Methane

NANOZ A mature technology now ready for scaling this year

✓ **Highly disruptive**

✓ **Proof of manufacturing**

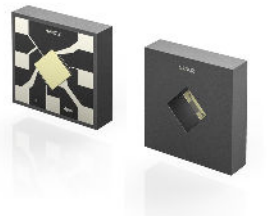
✓ **Mass production**

✓ **Already embedded into final devices**

✓ **Fixed the weakness of MOx technology**

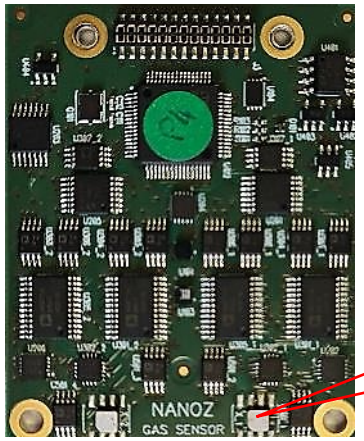
⇒ **Product maturity validated by 4 customers' Design-Wins**

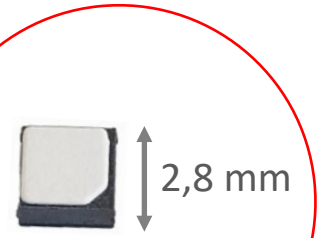
NANOZ Agenda



- **Market opportunity**
- **Ambition and Team**
- **Technology, offer and IP**
- **Hydrogen /Battery USE Case**
- **Methane Measurements**

NANOZ Gas detection in numerous applications tomorrow





Gas detection application

GAS

O3
Ozone

E-nose application

Diagnosis of diabetes, cancer,…

NANOZ Gas detection use case examples

Air quality in vehicle interior

NO2
Nitrogen dioxide

Defective heating system

CO
Carbon Monoxide

NANOZ GAS NANOZ

Safety in industry

H2
hydrogen

CH4
Methan

Food quality transportation

C2H4
Ethylene

Air purifier

HCHO
Formaldehyde

Electrical failure prevention in helicopter cockpit

O3
Ozone

NANOZ E-nose use case example

Detect presence of drug

Explosives detection

Diagnosis of diabetes, cancer,…

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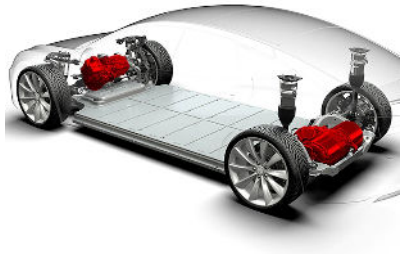
EV battery failure detection



Be sure your meat is eatable

Check presence of chemical products

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Solving major customer pain points

We don't find a sensor component combining the following specs :

1. *very small / embeddable*
2. *sensitive*
3. *free from calibration over time*
4. *low cost*
5. ***able to identify a single gas or a gas mixture specific to an event (Selectivity)***

⇒ NANOZ, the only existing solution solving all these pain points together

NANOZ

Paving the way for sensing any Gas, anywhere, anytime!

Mission
Make Gas Sensing possible in any device

Vision
Allow Gas Sensing to enable all mobile safety & wellbeing uses

Ambition
Dominate Gas Sensing applied to mobile devices

A seasoned Founding Team with Deep Tech experience

Thibaud Sellam
CEO,
Intl sales manager for CMR Group (large sensor manufacturer), Large account manager at Genoyer for turnkey intl projects

Walter Opschoor
Business Dev. Director,
several experiences in sales general management and entrepreneurship in mobile phone accessories and electronics.

Didier Noel
CFO,
almost 20 years within Philips ending up as Managing Director of an international Business Unit. 5 years in KPMG as Senior advisor and 5 years in technology transfer (SATT)

Highly experienced and engaged Advisers

Dr. Khalifa Aguir
Scientific Adviser,
internationally well-known scientist in Nano sensors, he holds a doctorate in microelectronics. Director of the micro-sensor activity at the CNRS laboratory in Marseille.

Lucien Brau
Strategic Adviser,
large semiconductor experience in Product and Business Development. He managed several Business Units and founded StarChip a successful startup acquired by Safran Group.

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NANOZ the future of the sensor market: MOx sensors

	Optical	Electrochemical	Mox (*)
Form			
Size	Ø 20 mm	Ø 9,2 x 12,4 mm	1,15 mm x 1,15 mm
Weaknesses	• Big size • High Power consumption • High price	• Recalibration required over time • Big Size for embedded application	• Selectivity

⇒ **MOx technology addresses all pain points of Optical and Electrochemical technologies**

⇒ **NANOZ fixes the only pain point of MOx technology : SELECTIVITY AND E-NOSE**

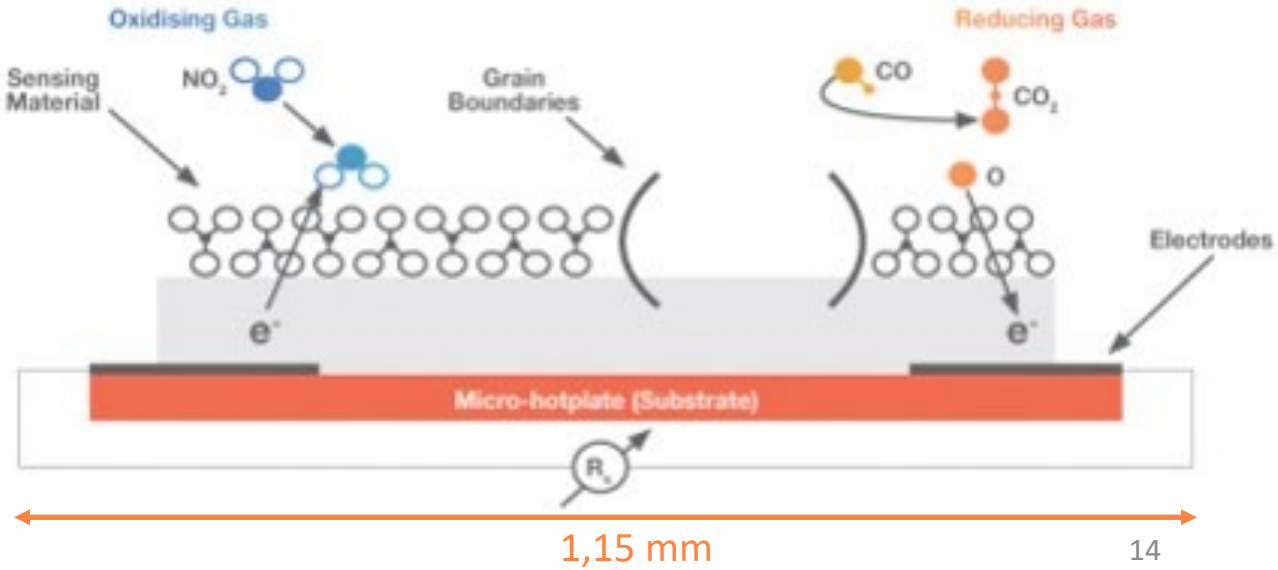
(*) Metal Oxide Semiconductor

NANOZ MOx sensor operation principle

How is MOx sensor made :
3 parts :
- Support (often in silicon)
- Transducer : electrical circuit
- sensitive layer

Support layer SILICON
Transducer (circuit)
Sensitive layer (Mox)

How is MOx sensor working :
Heating of a sensitive layer of metal oxide induces :
1. absorption/desorption of gas molecule
2. variation of the material resistance directly proportional to the gas concentration in air.



How NANOZ makes MOx technology selective

Thanks to the patent, NANOZ has got 4 sensors + 2 heaters on the same chip. The operation principle is based upon :

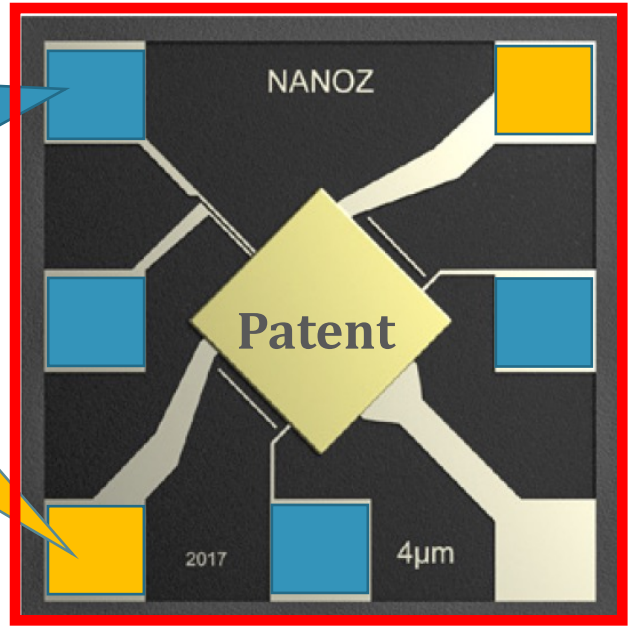
- 4 different signals coming out from the sensor for the same gas concentration
- AI algorithm processing the 4 signals

  ⇒ A unique and very accurate signature for each gas/concentration

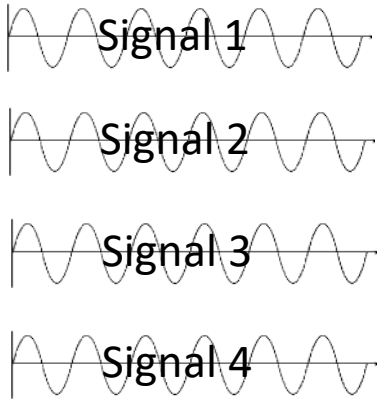
HW

Sensors x4 on the same chip

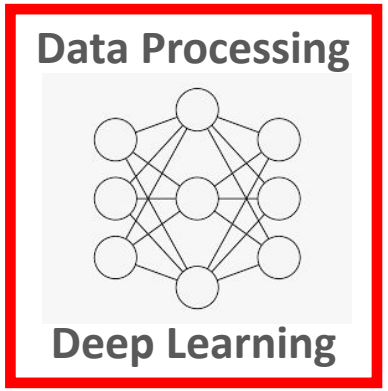
Heaters x2 on the same chip



1,15 mm



AI



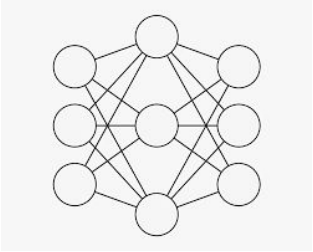
A unique and very accurate signature for each gas/concentration

NANOZ One single component for many gases

- Sensor component is dedicated to a group of gases
- Algorithm is dedicated to customer use case (one single gas or specific mix of gases for e-nose application)

AI Algorithm →

Data Processing



Deep Learning

→

- **Dedicated to customer use case** (one single gas or specific mix of gases) :
  - ⇒ Identification
  - ⇒ Concentration
- Embedded in microcontroller

Sensor component →

Sensitive layer (Silicon)

Transducer (circuit)

Support layer (Silicon)

→ Same for **many gases** (incl VOC, CO, Ozone, Ethanol,…)

→ Same for **all gases**

Nanoz offer delivered to customers

Gas sensor components (in reels)

Gas sensor component is a « standard » off-the-shelf product.
1st sensitive layer is SnO2 which enables to address a wide range of gases (Ethanol, VOC including Formaldehyde, Acetone,…)
⇒ the 1st industrialization of our gas sensor component is based on this layer.

AI algorithm (processing signals from sensor) is customized for each use case
Can be developed:

- by Nanoz using data base built upon customer use case simulation on our bench and Nanoz AI algorithm library
- or by customers themselves (then we'll deliver components only)

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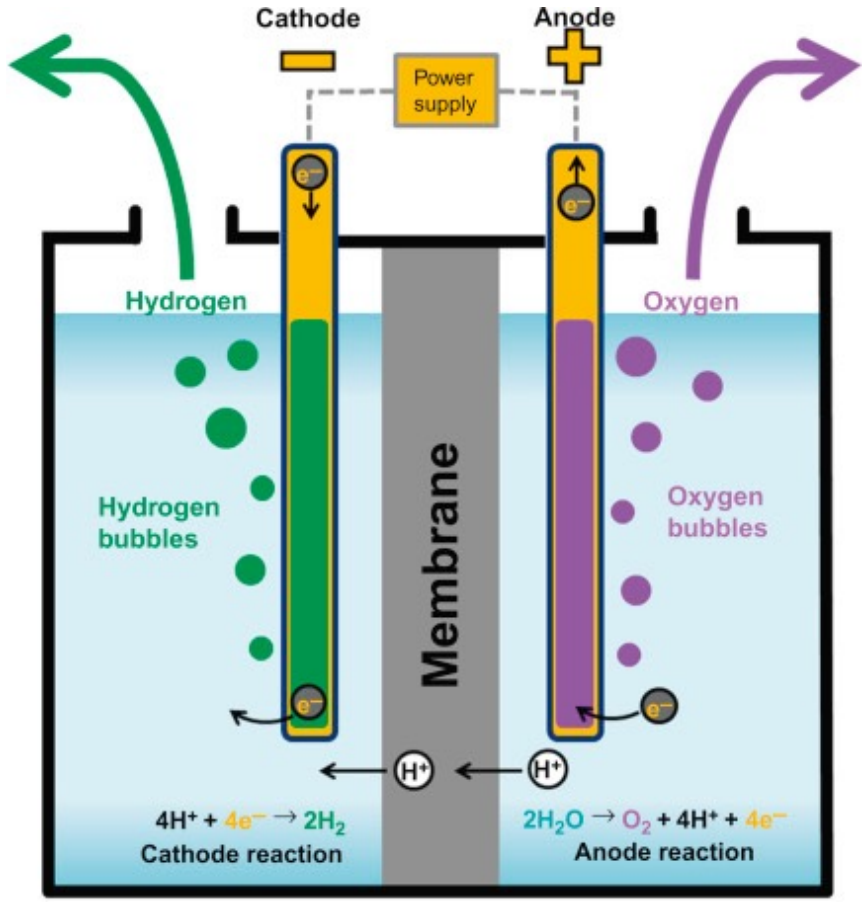
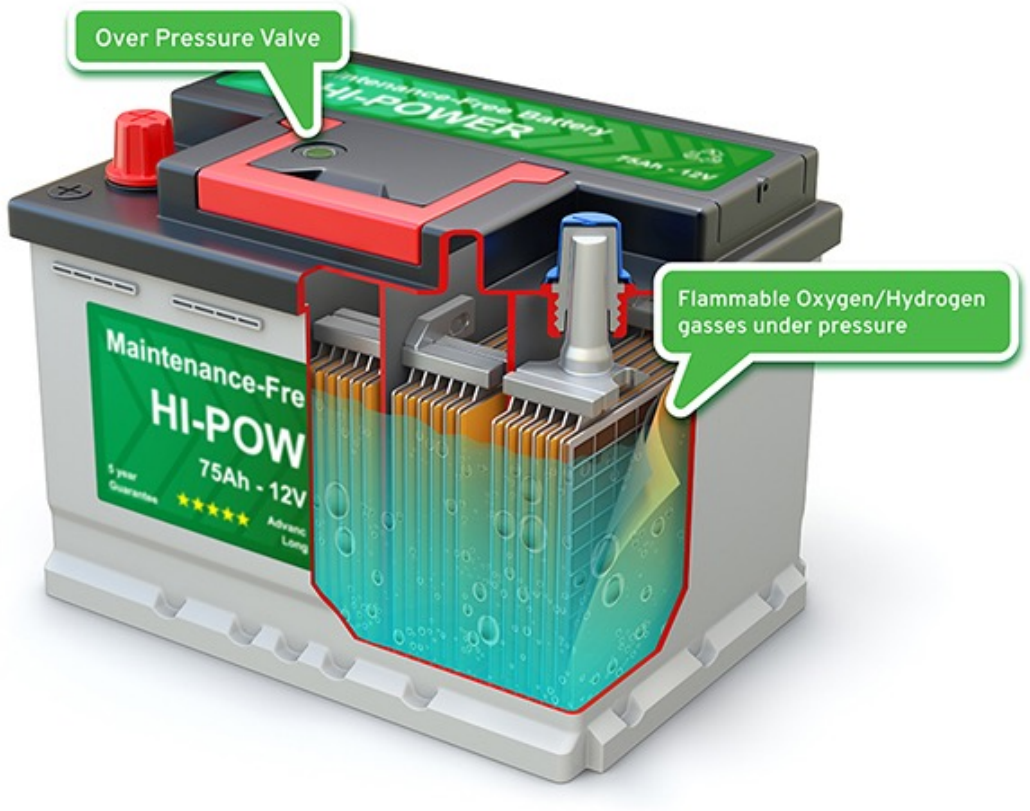
NANOZ Where can we find Hydrogen



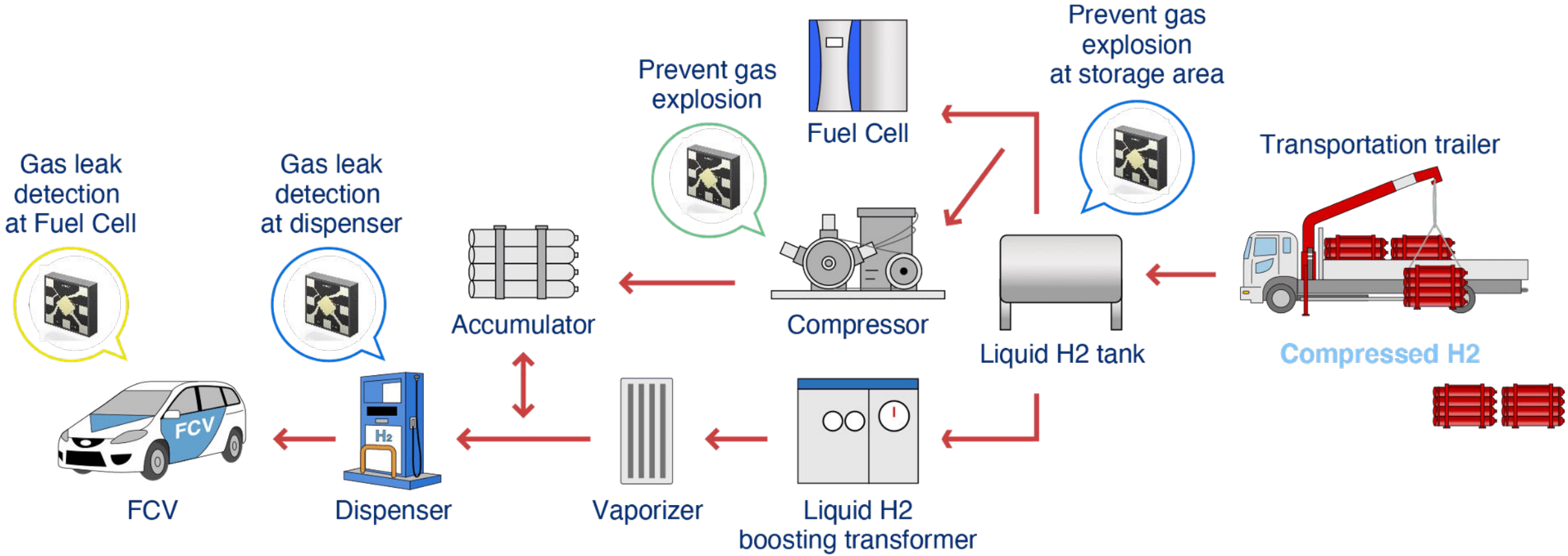
Production of Hydrogen



Hydrogen in Battery

NANOZ Hydrogen detection in the chain

As hydrogen becomes an even more popular choice across industries, it is crucial that any gas leaks can be detected quickly to prevent dangerous conditions. Installing Hydrogen sensor will increase the safe use of hydrogen in various applications.



NANOZ Use case for Hydrogen

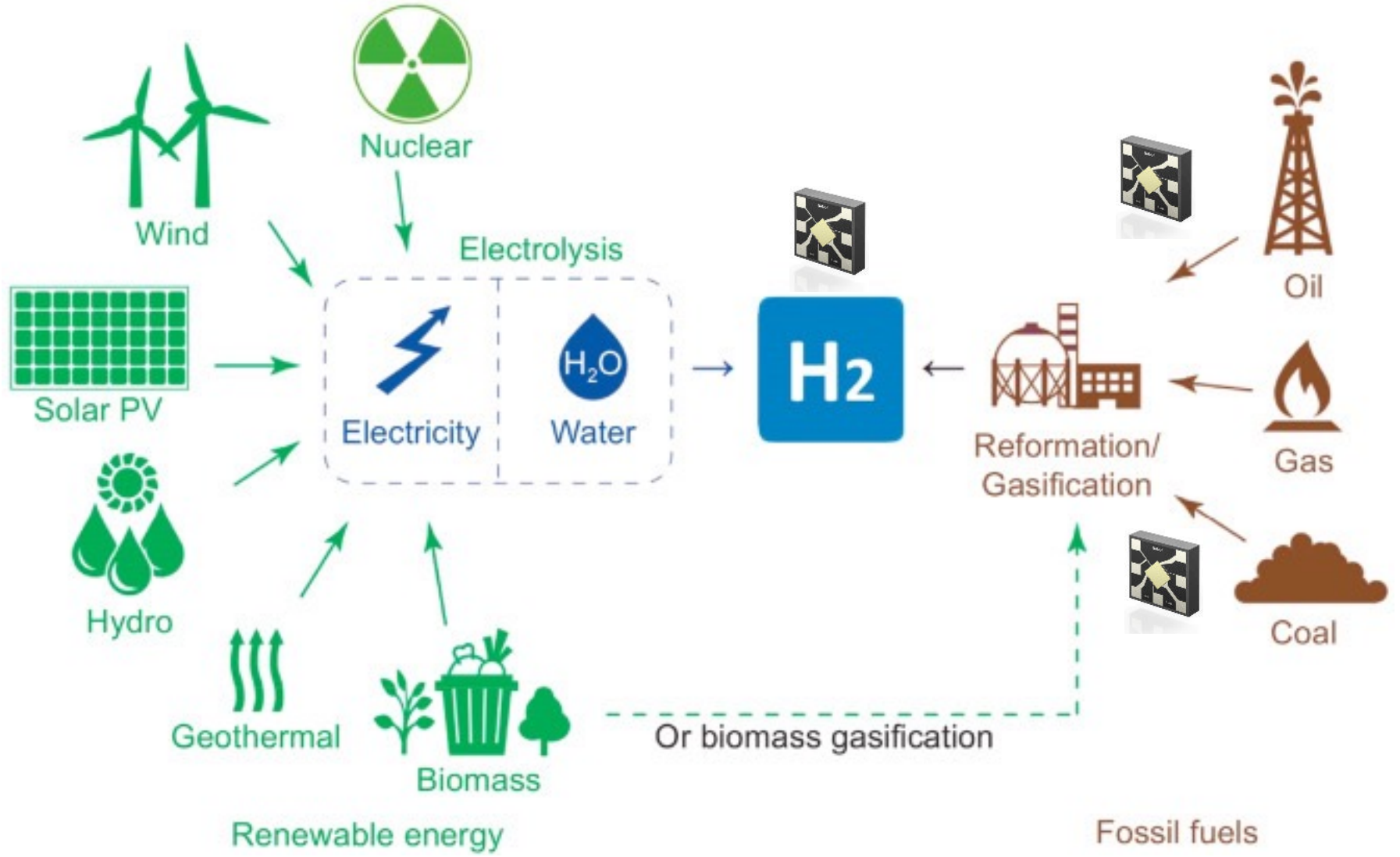
A. Hydrogen leak

Safety in the Hydrogen Production // Supply Chain

B. Unwanted release of Hydrogen

Inside the battery have hydrogen as well for storage/release to the device/Car, by damage Hydrogen is released, which will start a possible Thermal runaway

NANOZ Safety of Hydrogen production / Supply chain



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Sensor response to Hydrogen

NANOZ Use case for Hydrogen

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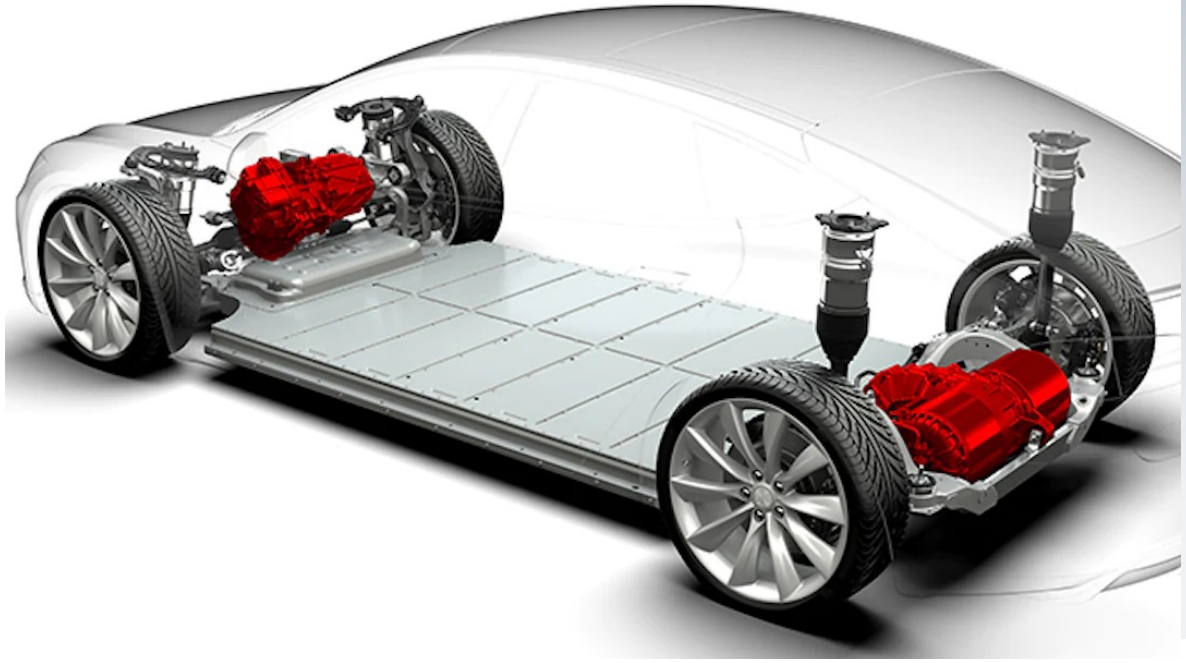
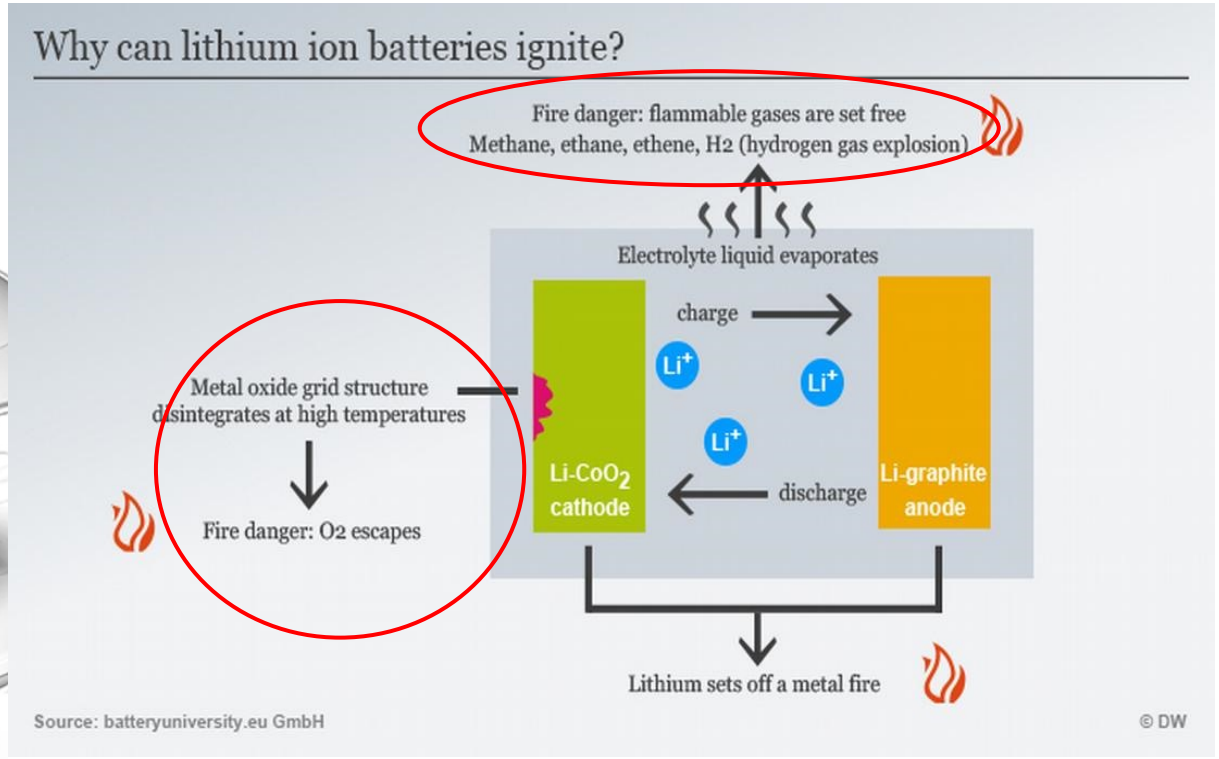
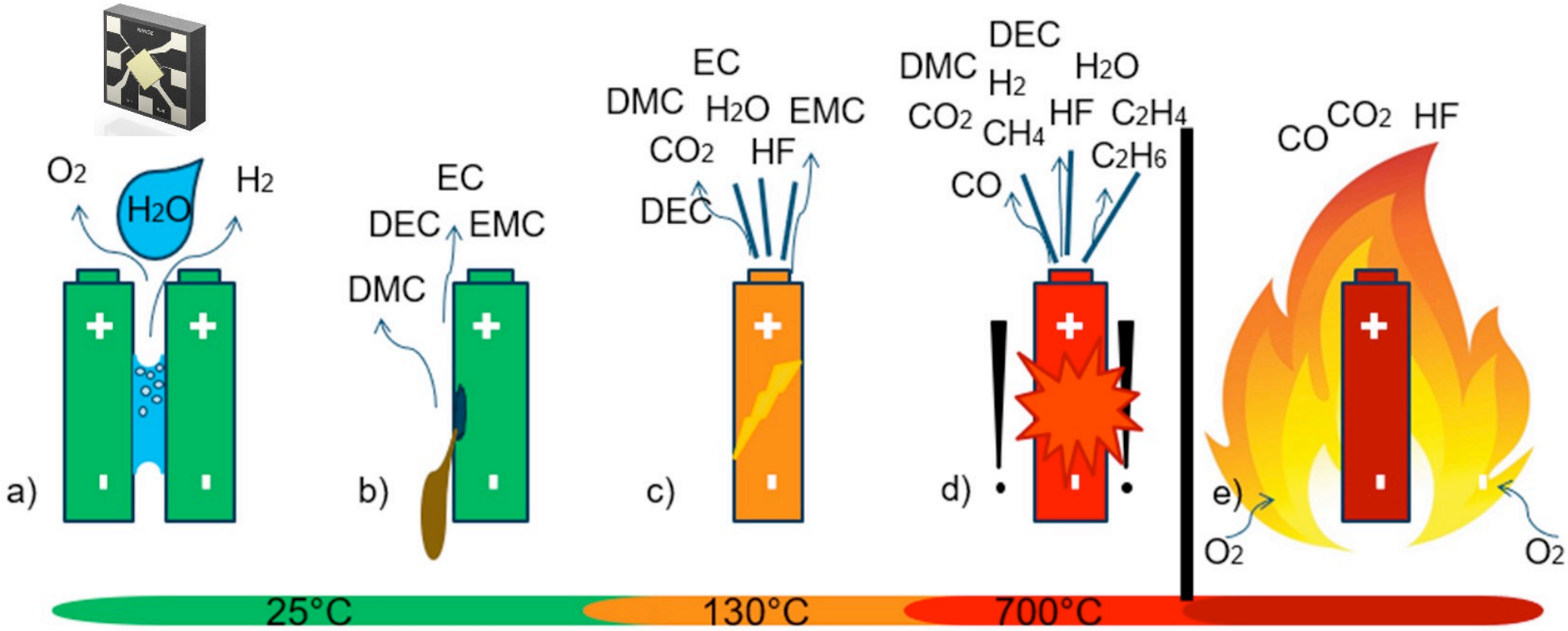
NANOZ Risk of Fire explosion with Hydrogen / Battery





Parameter	Cell Type #1	Cell Type #2	Cell Type #3	Cell Type #4
type	pouch	prismatic hard case	pouch	pouch
cathode material	NMC	NMC	NMC/LMO	NMC
anode material	graphite	graphite	graphite	graphite /LTO
electrolyte	EC:EMC (1:1)	EC:DMC:EMC (2:3:3)	EC:DEC:DMC (12:12:1)	EMC:PC:EC (4:2:1)
capacity	60 Ah	60 Ah	41 Ah	37 Ah
nominal voltage	3.6 V	3.6 V	3.8 V	3.6 V
gravimetric energy density	250 Wh/kg	225 Wh/kg	180 Wh/kg	190 Wh/kg
electrode design	stacked	2 jelly rolls	stacked	stacked

Gases released during the Thermal Runaway Of Battery Failure



Flammable gas

flammable, irritant, toxic, and/or corrosive

risk of explosion

Unwanted electrolysis

Vaporizing electrolyte of damaged cells

The first venting of a failing cell when the cell can opens above ~120–140 C in thermal abuse

Battery fire

Essl et al., Early Detection of Failing Automotive Batteries Using Gas Sensors. Batteries, 2021

NANOZ Gas sensor for early battery failure detection

	Reaction	Possible Event			Temperature	Battery type 1 Electrolyte 1	Battery type 2 Electrolyte 2	Battery type 3 Electrolyte 3	Battery type 4 Electrolyte 4	NANOZ
a)	Flammable Gas	UnWanted Electrolysis			25°C	H2 - O2				Yes (single gas detection)
b) Electrolyte	Flammable, Irritant .Toxic, Corrosive	Unwanted electrolysis	Vaporizing electrolyte of damaged cells	The first venting of a failing cell when the cell can opens above ~120–140 C in thermal abuse	25°C - 130°C	EC +EMC	EC + EMC + DMC	EC + DMC + DEC	EC + EMC +PC	Yes, E-nose detection
c)	Flammable, Irritant .Toxic, Corrosive	Unwanted electrolysis	Vaporizing electrolyte of damaged cells	The first venting of a failing cell when the cell can opens above ~120–140 C in thermal abuse	130°C	Electrolyte + H2O, CO2, CO, C2H6, H2, C2H4				Yes, E-nose detection
d)	Flammable, Irritant .Toxic, Corrosive	Unwanted electrolysis	Vaporizing electrolyte of damaged cells	The first venting of a failing cell when the cell can opens above ~120–140 C in thermal abuse	700°C	Electrolyte + H2O, CO2, CO, C2H6, H2, C2H4, CH4,C4H10, C2H2				N/A
e) Termal		Unwanted electrolysis	Vaporizing electrolyte of damaged cells	The first venting of a failing cell when the cell can opens above ~120–140 C in thermal abuse	Explosion	CO, CO2 + HF (02)				N/A

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Methane (CH4) preliminary results

- Example of sensor current versus time for several [CH4]
- Exposure time 5 min