nanoscent

Technology Specifications

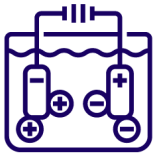
Project 961108

Spec Sheet VOCID® H2Confirm

NanoScent's VOCID® H2Confirm, is a sensor-based monitoring system designed to be applied to various points of the hydrogen supply chain, from production to storage and refueling stations, for the continuous monitoring of hydrogen purity in realtime and in-line. VOCID® H2Confirm measures gases, volatile organic compounds (VOC) and hydrogen impurities onsite and provides real time alerts in the event of contamination or when hydrogen purity levels fall below a pre-programmed threshold. As a result, hydrogen supply and operations are efficiently monitored. Target customers and use cases of VOCID® H2Confirm include:

Hydrogen Production

H2-based Transport and Fuel Cells



Electrolyzer Producers

Logistics: Storage & Distribution

Hydrogen Refuelling Stations

VOCID® H2Confirm offers companies an innovative service for monitoring their manufacturing processes, including the purity or cleanliness of their production machines, while providing results in minutes-time, indicating whether the supply is clean with pass / fail results.

VOCID® H2Confirm System Description

Customer Interfaces	
Product Requirement	
Modular System	Specialized sensors combined for different customers' needs
Operational Run Time	24/7
Electricity	24V
Connectivity	Modbus
Sample Gas	Hydrogen 5.0 free of oil mist, dry gas
Gas Temperature	0- 50°C
Gas Humidity	Dry gas, <50ppm
Gas Pressure	< 3 bar
Integration	In Line via bypass
Connection	1/8 inch, SS
System Outlet	Integrated to the customer's vent system (1/8 inch)
Size in Volume	100L
Weight	40 Kg
Note:	Since the measurement is relative, a reference gas (Hydrogen 5.0) is needed. A reference cylinder of 10 lit @ 90 bar is sufficient for 16 measurements (2 measurement/ hour)

Safety and Validation	
Product Requirement	
ATEX	Based on customers' requirements
Electrical Safety	All electrical components (digital communication and power) pass through intrinsically safe barriers.
V&V	External Validation

Environmental Conditions	
Product Requirement	
Temperature	< 50°C

Measurement/ Sensor Specifications	
Product Requirement	
Threshold Alarm	Modular: O2 at 5 ppm H2O at 5 ppm N2 at 200 ppm CO at 200ppb VOCs based on customers' requirements
Measurement Frequency	4/ hour
Time to Result	<12 minutes

Reporting	
Product Requirement	
Measurement Output	Pass/ Fail (Above/ below a threshold)
System Alarm	System integrity alarm (temperature, pressure and sensor viability)
Report	Available

Maintenance and Handling	
Product Requirement	
Sensor Handling	1 / month depending on the Module
Warm-up procedure (after sensor handling)	2 hours under pure H2 @ flow rate of 1 Lit/min
Ready-to-use procedure (after downtime)	2 hours under pure H2 @ flow rate of 1 Lit/min
Downtime	In the event where downtime (planned or unplanned) exceeds more than 2 HOURS. 'Ready-to-use' procedure is required.
Sensor Storage Conditions	Ambient temperature in a designated box

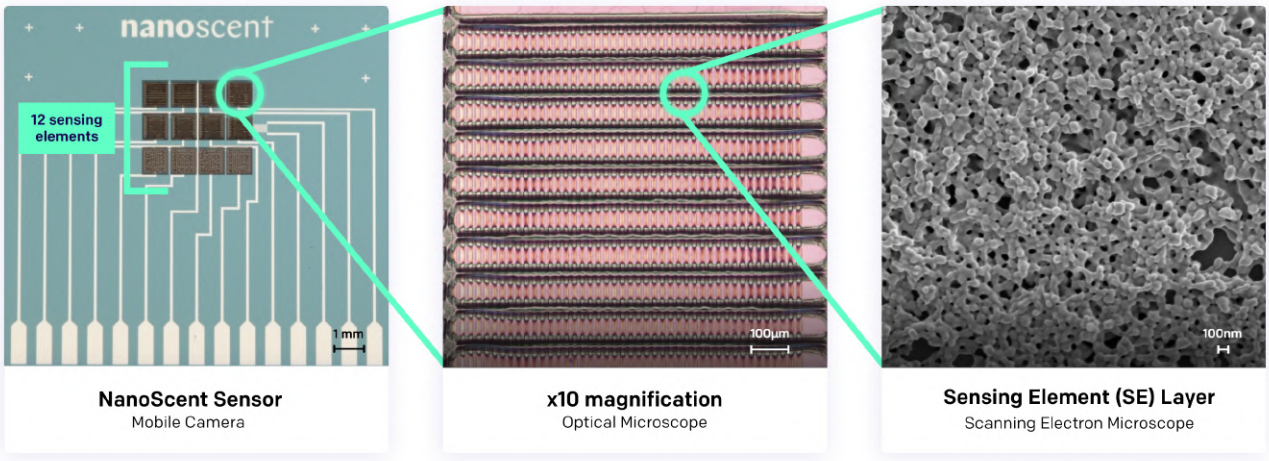
About the VOCID® System

VOCID® H2Confirm runs on chemiresistor technology and provides sensitivity as low as ppb level for various gasses and volatile organic compounds (VOCs).

Sensors

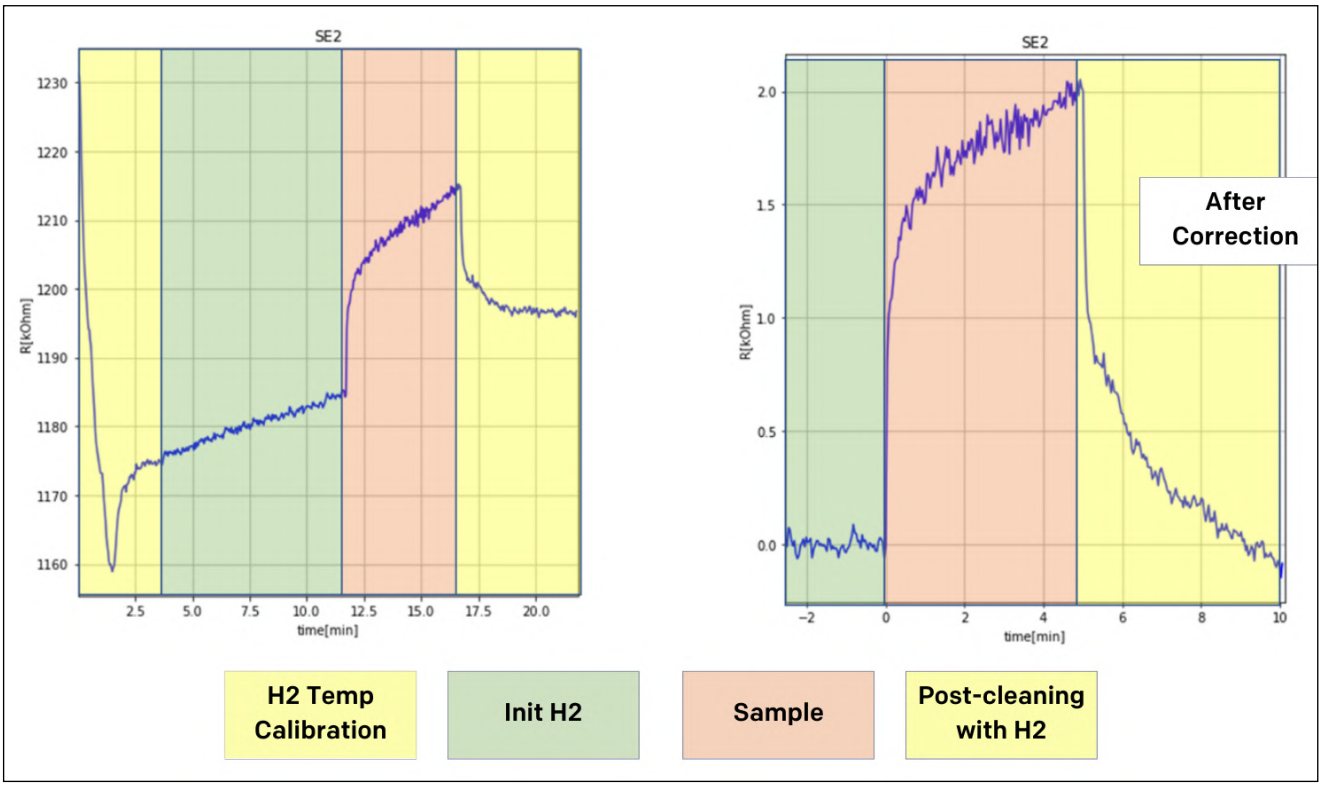
At the core of the VOCID® H2Confirm platform are the patent-protected sensors are integral to the detection and monitoring process of gasses and VOCs.

The image below shows the NanoScent sensor under progressively increased magnification, demonstrating our use of nanoparticles which react with gasses in order to provide a measurement.



The sensor is composed of a combination of reactive molecules (often organic) and metallic core which act as the electrical conductor, all printed onto a chip containing several different metal and reactive molecule combinations (i.e. sensor array). When exposed to gasses, individual reactive molecules display different reaction profiles which are measured based on the electrical profile generated in the conductive parts. Different compositions of reactive molecules on the sensor will react to different materials, allowing the set up of different reactive arrangements for different sensing applications.

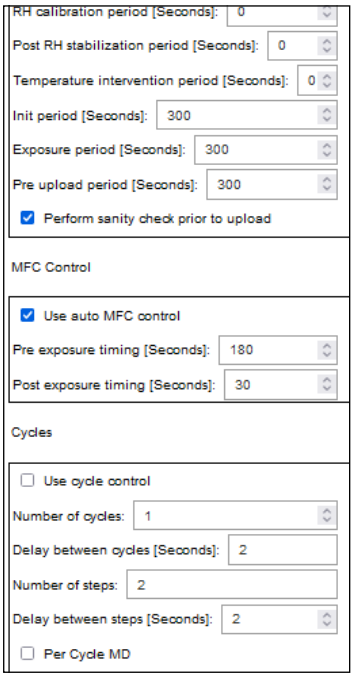
Sensor Response



1. **Temperature Calibration with H2**: Used to measure a calibration curve of each sensing element measuring the response to different temperatures.
2. **Init with H2**: Creates a baseline based on the sensors' reading of reference H2.
3. **Sample Exposure**: Delivery of the sample to the sensor.
4. **Post Cleaning with H2**: Used to wash any residues of sample gas from the sensors.

The 'After Correction' signal demonstrates the response of the sensor after you calibrate the response based on the calibration curve and the Init phase.

Data Acquisition & Analysis

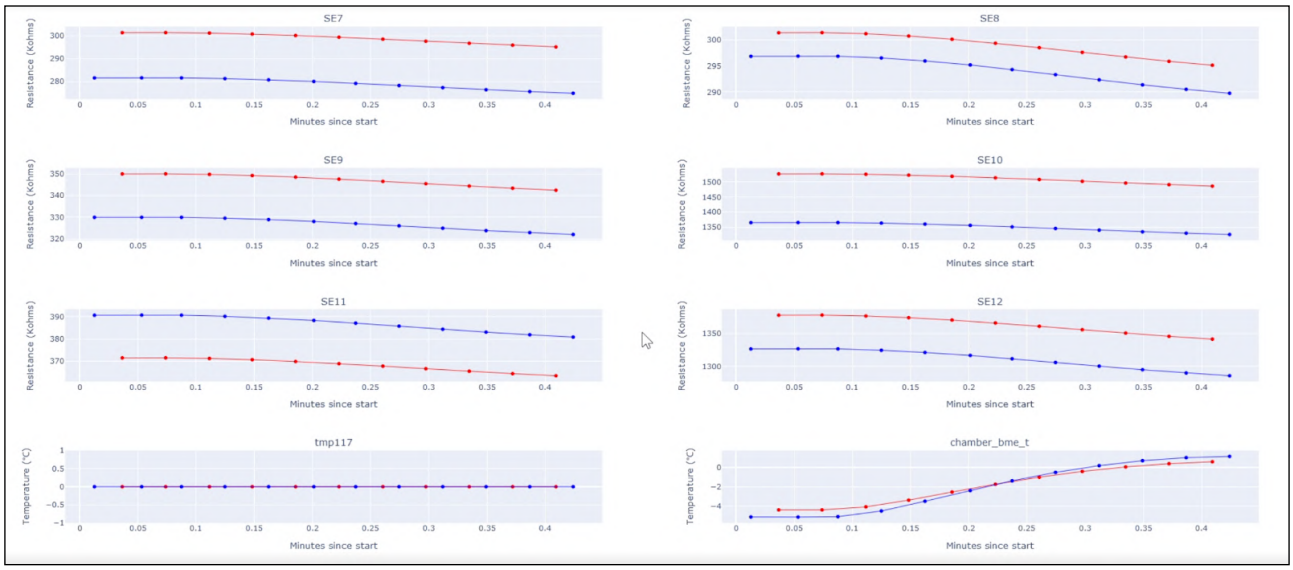


NanoScent can perform hundreds of tests continuously and automatically. This is achieved by simple operation of the NanoScent software that is run by Jupyter notebook. The software allows the user to control multiple parameters depending on the experimental set up.

Among these parameters, the user can define:

- The environmental conditions like humidity and temperature (this will be used later on for calibration)
- The number of sensors to test in parallel
- The number of measurements
- The period of each measurement
- The phases included on each measurements
- Type of gasses to expose and their concentration

The software has a live view dashboard which shows real time readings of the measurement, including all sensing elements, temperature, humidity and pressure sensors. On the image below, two devices are presented with each device being colored differently (i.e., red and blue).



Data Analysis

Using its proprietary software, NanoScent has the ability to analyze thousands of measurements collected over hundreds of hours and from multiple devices. Data collected is uploaded to AWS after each measurement where it is being processed and analyzed. Analysis software is used to determine whether the signals collected from the sensors are indicative of a contamination (i.e. responses are above a pre set threshold for one or more of the sensing elements) or whether they are at the range of normal (i.e. responses are below a threshold for the different sensing elements).

NanoScent also has a database in order to learn the effect that different parameters have on the sensor's responses. All data is automatically fed to the database starting from synthesis, through sensor production and sensor exposures. Tens of parameters for each synthesis are recorded and being used by the R&D team on a daily basis.

A video showing more about data acquisition and analysis can be found in the following link: https://youtu.be/hAojdFvIRQU

Methods of Measuring with VOCID® H2Confirm

There are two main ways of measuring hydrogen quality with VOCID® H2Confirm:

1. **Spot measurements**: To perform spot measurements, a sample is collected from an electrolyzer or from a refueling station into a cylinder and placed near a reference gas cylinder and provides a measurement.

2. **In-line measurements**: In-line measurements require for the VOCID® H2Confirm device to be integrated directly into the gas line.

Detecting Gasses and VOCs

The table below describes the lowest measured concentration (LMC) for each analyte. It is different from LOD because the concentrations in the table are the lowest we were able to produce with high certainty, the expected LOD can be lower. To produce the analytes, we either use an automated dilution system (DS) or a gas generator (GG) which is able to produce gasses down to the ppt level.

Important to mention that only few of the gasses/VOCs below were validated externally (as indicated under "Notes" in the chart below).

Gas / VOC	CAS	LMC (PPB)	Measurement Method	Notes
1-pentene-3-one	1629-58-9	1000	DS	
2-methylbutanal	78-78-4	1000	DS	
Acetaldehyde	75-07-0	1000	DS	
Acetic Acid	64-19-7	1000	DS	
Acetone	67-64-1	10000	GG	
Ammonia	7664-41-7	100	GG	Validated by NPL under H2; Relevant for ISO-14687
Carbon Monoxide	630-08-0	200	DS	Validated by NPL under H2; Relevant for ISO-14687
Carbon dioxide	124-38-9	100	DS	Relevant for ISO-14687
Dichloromethane	75-09-2	2000	DS	
Dimethyl Trisulfide	3658-80-8	600	DS	
Ethylene	74-85-1	5000	DS	
Formaldehyde	50-00-0	4000	GG	Relevant for ISO-14687
Formic Acid	64-18-6	100	GG	Relevant for ISO-14687
Heptanal	111-71-7	10	GG	
Hydrogen Sulfide	7783-06-4	20	DS	Relevant for ISO-14687
Methane	74-82-8	8000	DS	Relevant for ISO-14687
Methyl Salicylate	119-36-8	600	DS	
Nitric Oxide	10102-43-9	500	DS	
Nonanal	124-19-6	0.15	GG	
Octanal	124-13-0.	10	DS	
Oxygen	7782-44-7	5000	DS	Validated by NPL under H2; Relevant for ISO-14687
Tetrachloroethylene	127-18-4	1000	DS	

Gas / VOC	CAS	LMC (PPB)	Measurement Method	Notes
Toluene	108-88-3	500	GG	Relevant for ISO-14687
Trans-2-nonenal	18829-56-6	600	DS	
Water	7732-18-5	5000	DS	Validated by NPL under H2; Relevant for ISO-14687
Xylene	1330-20-7	1000	DS	

LMC= Lowest Measured Concentration; **PPB**= Parts per Billion;
DS= Dilution System; **GG**= Gas Generator

Patents

For the VOCID® system, NanoScent has the following patents:

FILE NO.	COUNTRY	APPLICATION NO.	TITLE
NASE-P-002-EP	European Patent Office	EP198265571	PARTICLES FOR CHEMIRESISTOR SENSOR
NASE-P-002-JP	Japan	2020571751	PARTICLES FOR CHEMIRESISTOR SENSOR
NASE-P-002-KR	Republic of Korea	1020217002280	PARTICLES FOR CHEMIRESISTOR SENSOR
NASE-P-002-US	United States of America	17255439	PARTICLES FOR CHEMIRESISTOR SENSOR
NASE-P-003-IL	Israel	279967	SENSING ELEMENT FOR CHEMIRESISTOR SENSOR AND METHOD OF MAKING SAME
NASE-P-003-JP	Japan	2021500831	SENSING ELEMENT FOR CHEMIRESISTOR SENSOR AND METHOD OF MAKING SAME
NASE-P-003-US	United States of America	17257030	SENSING ELEMENT FOR CHEMIRESISTOR SENSOR AND METHOD OF MAKING SAME
NASE-P-004-US	United States of America	17614351	METHOD AND DEVICE FOR IDENTIFYING VOLATILE COMPOUNDS
NASE-P-005-US	United States of America	17/781,436	USE OF A CHEMIRESISTOR SENSOR FOR IMPROVING HEALTH
NASE-P-009-US	United States of America	17/799,120	SYSTEM AND METHOD FOR COLLECTING AND SENSING VOLATILE COMPOUNDS
NASE-P-010-US	United States of America	17/495,499	NANOPARTICLES FOR CHEMIRESISTOR SENSORS
NASE-P-010-US1	United States of America	17/690,322	NANOPARTICLES FOR CHEMIRESISTOR SENSORS
NASE-P-010-US2-CIP of US	United States of America	17/722,857	NANOPARTICLES FOR CHEMIRESISTOR SENSORS
NASE-P-010-PCT	PCT	PCT/IL2022/051067	NANOPARTICLES FOR CHEMIRESISTOR SENSORS
NASE-P-011-USP	United States of America	63/445,323	NANOPARTICLES FOR CHEMIRESISTOR SENSORS
NASE-P-012-USP	United States of America	63/450114	CHEMIRESISTOR SENSOR WITH IN-SITU TEMPERATURE CALIBRATION AND METHOD FOR CALIBRATING SAME

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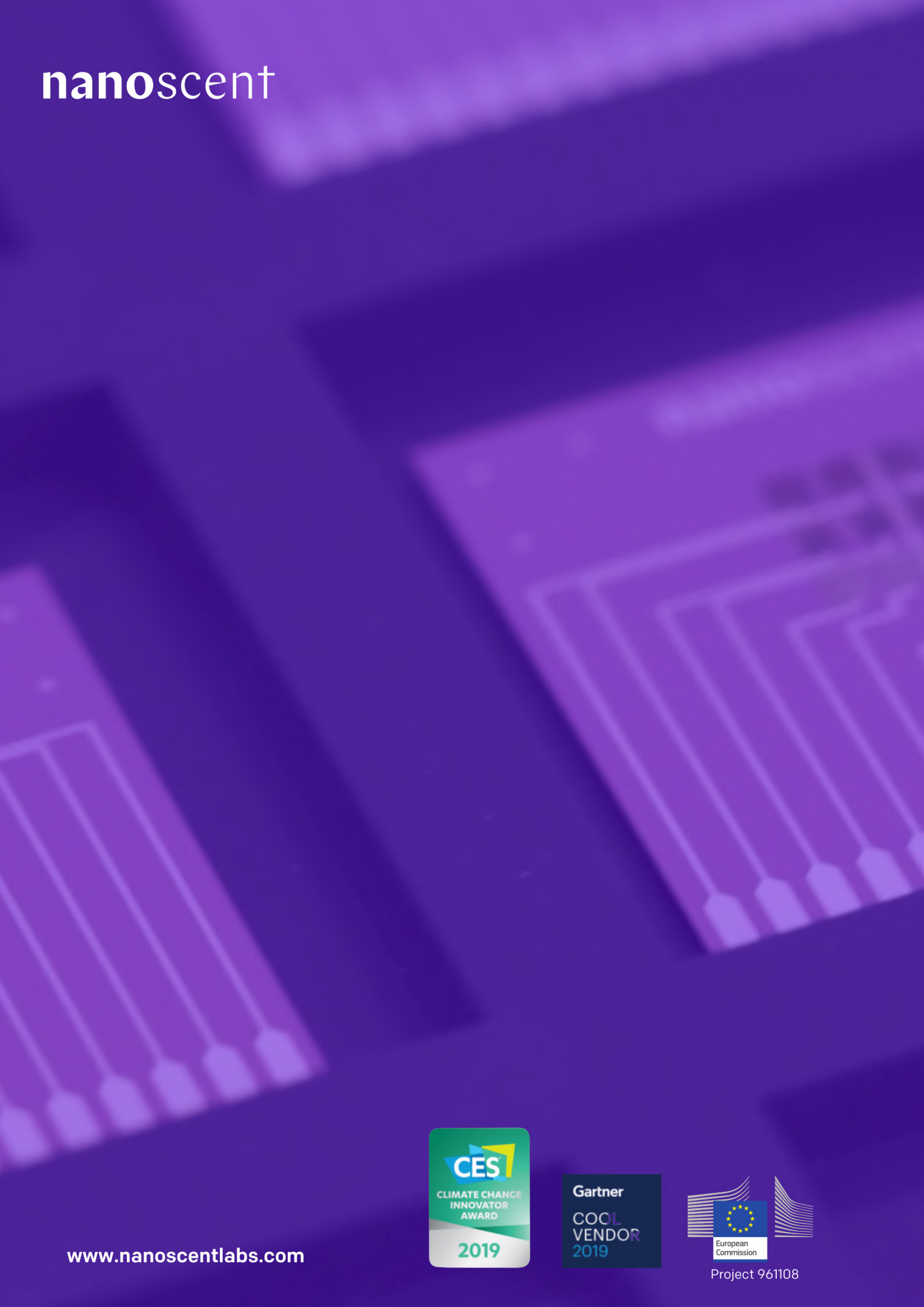

CES CLIMATE CHANGE INNOVATOR AWARD 2019

Gartner COOL VENDOR 2019

European Commission

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