

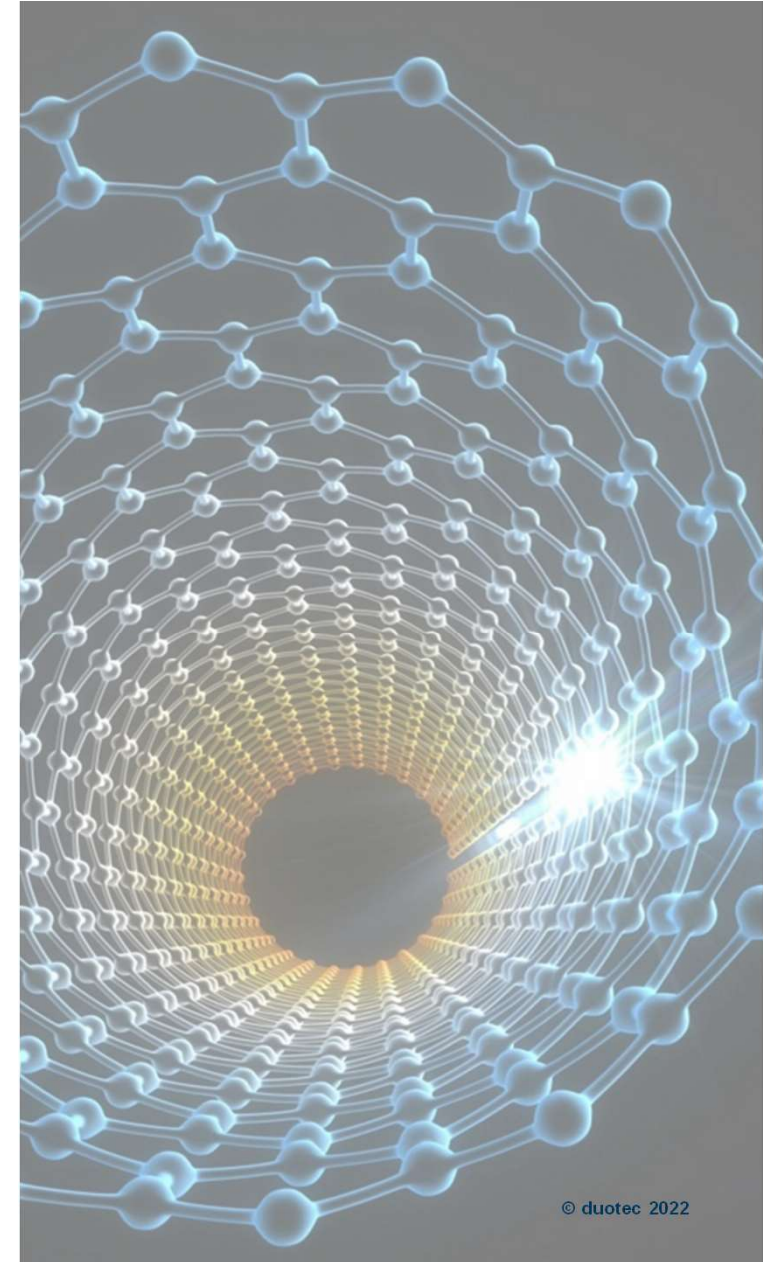
duotec eNose presentation | Jan. 2022

duotec[®]
Ahead of innovation.



AGENDA

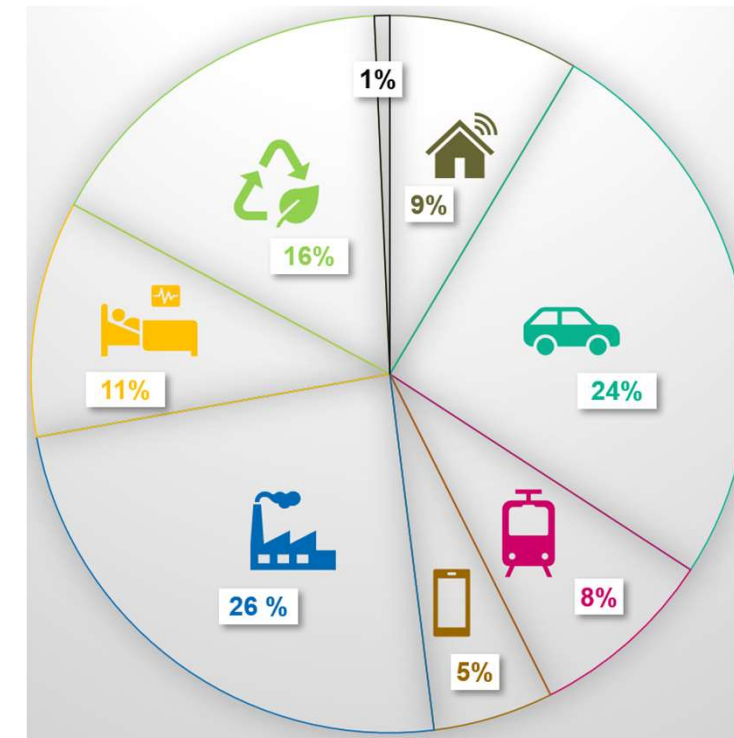
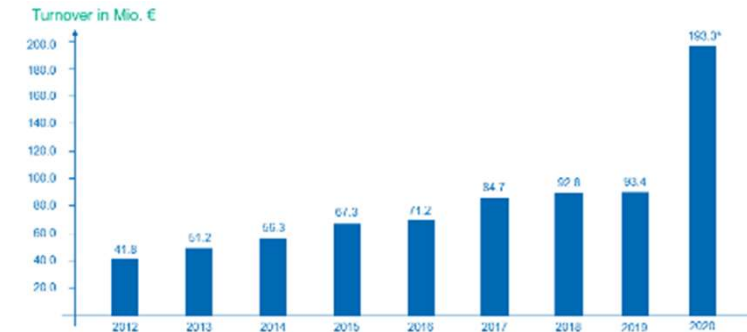
- duotec
- Vision eNose
- SmartNanotubes Technologies GmbH
- Real new development - cutting edge
- Carbon Nanotubes
- Production, implementation
- Fields of application
- To the customized solution



about duotec

Company presentation in 1 slide

- Founded in 1965 by Hans & Werner Turck, still family owned today
- Natural growth until 2020: Headquarter in Halver, subsidiaries in USA, Interprox CH, Germany, Mexico, more in acquisition
- Acquisitions: mlands, WIS and further majority holdings: SmartNanotubes, Quantum Technologies, ...
- Global Footprint: 842 employees, 5 production sites, 3 development sites
- Sales 2020: 193.3 M€
- EMS, E²MS, ODM Platforms & Technologies





VISION - DIGITIZING SMELLS

Let Alexa and Siri monitor your air quality



*Alexa, ...
tell me
what's that
funny smell?*



Smell iX16 inside*

*...These are
overripe fruits,
please check the
fruit basket*



Smell iX16 inside



Smell iX16 inside

*Smell iX16 is a smell detector chip for electronic nose application, manufactured by SmartNanotubes



SMARTNANOTUBES TECHNOLOGIES GMBH

2017 – 2020 Spin-off project at Life Science Incubator Sachsen
(2 Mio. EUR grant from BMBF)

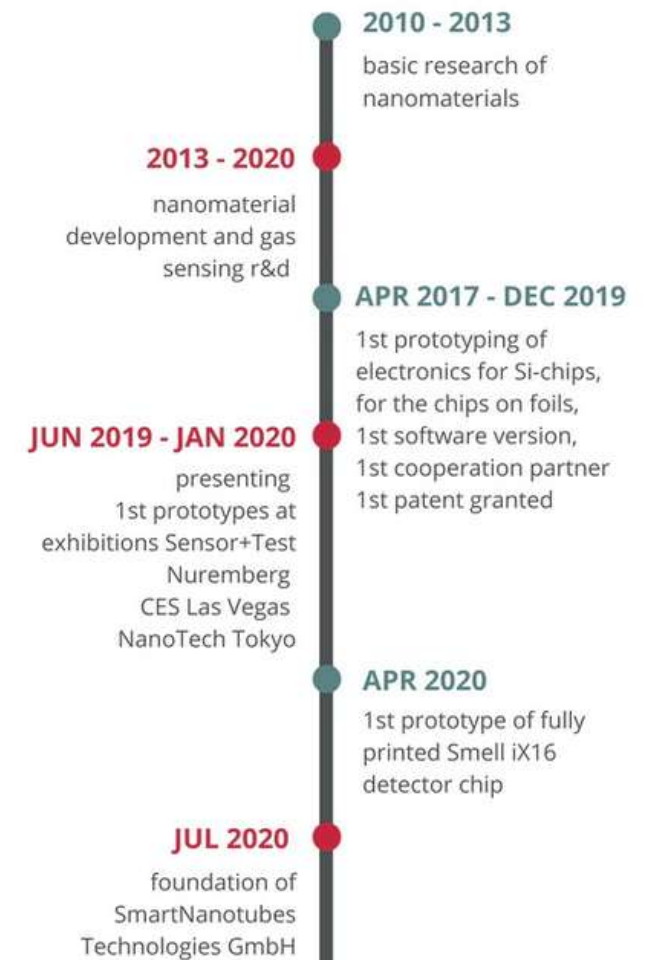
Founding date: 23.07.2020

Registration number: HRB 40252

Seed Round completed: Sep 2020

Round A: March 2021

Acquisition of SNT by Turck duotec GmbH: 2021





PROCESS + PORTFOLIO

Process & portfolio of SNT

(1) Synthesis

patented SWCNT (single-walled carbon nanotube) cloning process: Substrate (Wafer), Gas mixture, Temperature, Time

(2) Printing

proprietary Ink formulations
Electrodes, CNT-Ink, Functionalization

(3) Sensor Development

proprietary knowhow
New detector design, Validation, Production





COMPARISON

Gas Sensor Arrays

low sensitivity - high power consumption - large size

Game changers:

new material - AI based software

SNT's solutions

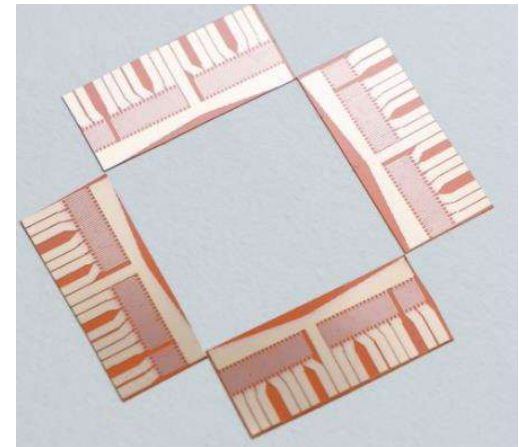
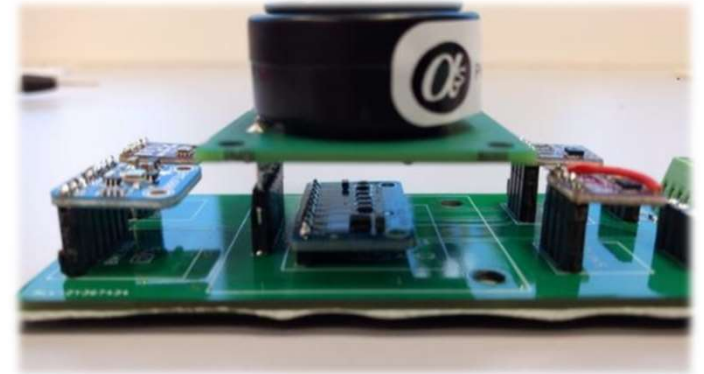
highly sensitive : 10 ppm → 0.1 ppm

energy-efficient : 1 mW → 0.001 mW

single gas sensor → electronic nose

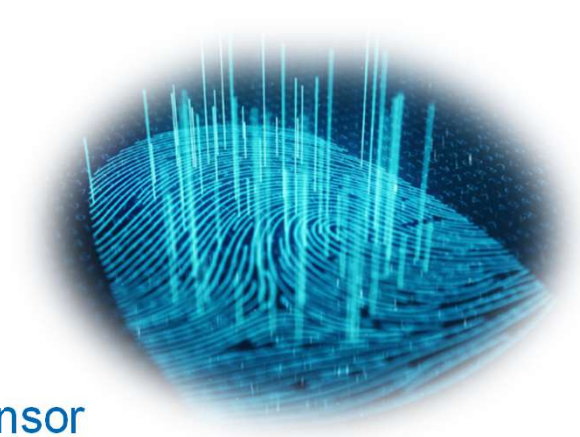
1 detector → 64 detectors

compact - low cost





DEMAND AND IMPLEMENTING



A multi-gas sensor that mimics the nose of humans/animals!

- Conventional gas sensor technology = specialization on specific sensor materials.
- SNT's approach is different, we use:
 - **Complex Pattern Recognition.**
- **Learning phase**
 - multiple sensor elements/channels measure the odor patterns (raw data)
 - SNT proprietary software tools: ML & AI detect and distinguish.
 - A constantly growing database of reference odors is created.
- **Use phase**
 - Customized odor results are stored on your sensor module
 - Odors or odor patterns are reliably detected directly in your application
- Numerous gases, VOCs, odors (including fresh and spoiled food) have shown very good test results. One focus is **fire prevention** by early detection of overheating with specially developed warning substances.



FIRST OWN PRODUCT

Developer Kit

- High sensitivity to various gases and VOCs (Volatile Organic Compounds)
- Cost-effective, scalable inkjet printing technology
- Very compact modular: easy adaptation to specific applications
- Can be used as disposable chips
- Very low power consumption: $< 1 \mu\text{W}$ on chip, $< 300 \mu\text{W}$ for readout electronics
- Software compatible with mobile devices
- Connection via USB, Wi-Fi or Bluetooth compatible with Arduino and Raspberry Pi

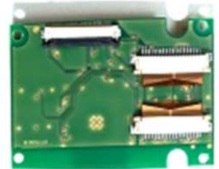
Smell.
iX16



16-channel detector on foil



Smell.
BOARD iX16x4



Board 4x 16-channel detectors on foil in ZIF sockets

Smell.
INSPECTOR



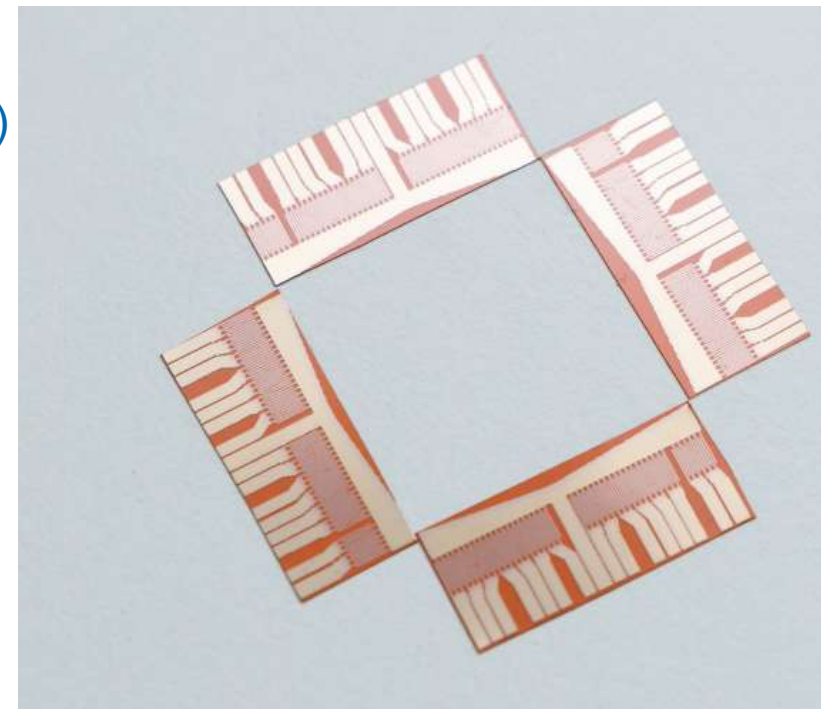
Device, includes smell board iX16x4 and software



KEY UNIT: SMELL IX16 DETECTOR

- Completely manufactured by inkjet printing process
- Semiconducting SWCNTs as sensor material
- Carrier material: Kapton or PET (Polyethylenterephthalat) film
- 16 independent gas detectors (channels) on one chip
- The functionality of each of the 16 channels can be adjusted
- Different Smell iX16 can be combined to meet specific use cases
- Designed for 22-pin ZIF socket (1 mm pitch)
- Supplied with particle filter (dust protection)
- Power consumption approx. 1 μ W

Smell.
iX16



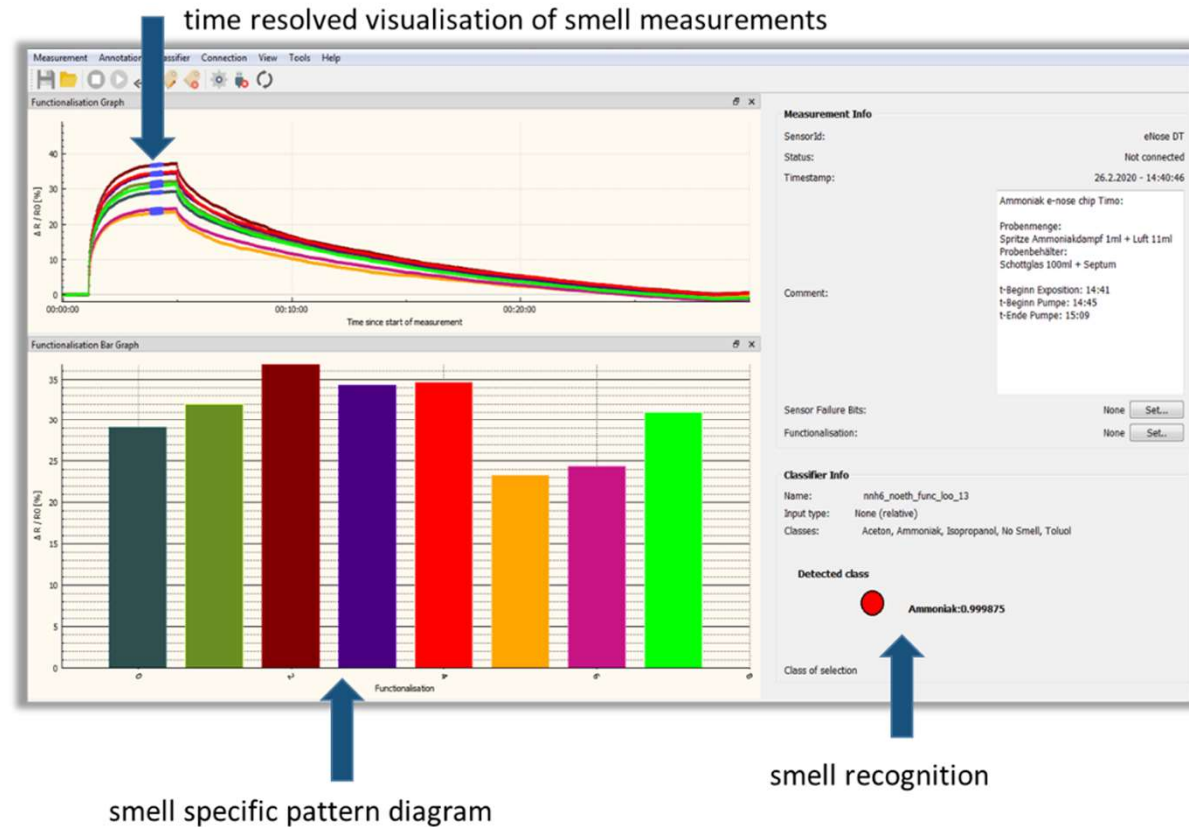


SMELL ANNOTATOR SOFTWARE

Smell.
ANNOTATOR

One software for developers and end users

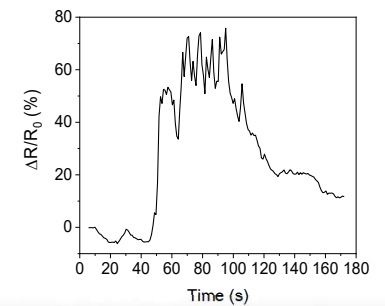
- for displaying, commenting and saving measurements
- provides various sensor parameters
- for detection of stored odors
- Windows and Linux versions available
- Android and iOS to follow

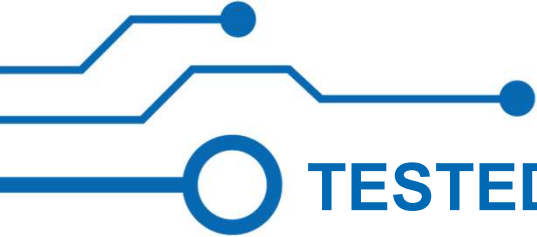


APPLICATION EXAMPLES

SNIFFBOT

- A project at TU Dresden to develop an autonomous drone-based system to search for sources of harmful gases.
- Stable signal while standing and flying.
- Reliable and fast detection when the drone is close to the NH₃ (ammonia) source.
- Fast recovery when the drone flies away from the NH₃ source..





TESTED GASES, VOCS AND SMELLS

	classified	fresh	spoiled
Food & Beverage 1	Red wine, coffee, lemon and orange juice, garlic, vodka, onion, orange, chocolate, tea, ...	X	
Food & Beverage 2	Meat, fish, banana, ...	X	X
Gases	NH ₃ , H ₂ O ₂ , CH ₂ O, CO ₂ , C ₂ H ₅ OH, PH ₃ , H ₂ S, C ₇ H ₈ , NO, C ₃ H ₆ O, C ₈ H ₁₀ O ₃ , C ₄ H ₈ O, C ₉ H ₁₀ O ₂ , C ₆ H ₁₂ O, C ₈ H ₁₆ O, ...		
msc.	Perfume, household waste, Guaiacol , ...		
tbd	tbd		

ammonia, nitrogen monoxide, phosphine, carbon dioxide, hydrogen sulfide, ethanol, acetone, isopropanol, toluene, hydrogen peroxide, formaldehyde, 2,6-dimethoxy-phenol, 2-methoxy-4-vinylphenol,



APPLICATION POSSIBILITIES

Unlimited number of use cases: Wherever odors play a role!



Home Appliances

Industrial Appliances

Air Quality

Safety & Security

Quality Control

Food & Beverages

Healthcare & Medicine
Drones & Robots
Automotive & Aviation
Perfumes & Body Care
Agriculture & Product Safety
Research & Development
...and many, many more...



HOW TO START COOPERATION

5 steps to satisfaction

- (1) **Workshop** → Get to know customer use cases, work them out, find first solutions: HW, SW/FW/database, mechanics, connectivity.
- (2) **Feasibility** phase → Support decisions, reduce risks
- (3) **Specification** phase → Identify and define specifications, normative + regulatory requirements, validation, etc.
- (4) **Realization** → demonstrator/mock-up, A to D prototyping, qualification, certification, verification & validation.
industrialization for serial production, series
- (5) **Customer support**, after sales & product improvements



THE CARBON NANOTUBES FUTURE

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