TOWARDS ATMOSPHERIC RADICAL SENSING: FABRICATION OF JUNCTIONLESS TRANSISTORS

RADICAL
A Fundamental Breakthrough in Detecting Atmospheric Radicals.

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The RADICAL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 899332.

MOTIVATION

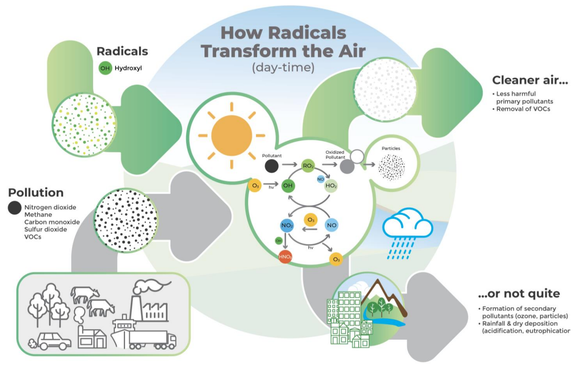
400 000 premature deaths in the EU every year are linked to air pollution

Particulate matter and nitrogen dioxide are the main urban pollutants and are **very harmful** to **human health**

Air pollution costs over **€4 billion in healthcare** and **€16 billion in lost workdays**

About **130 cities** across Europe do not meet EU air quality standards

72 % of Europeans want **public action** to improve air quality



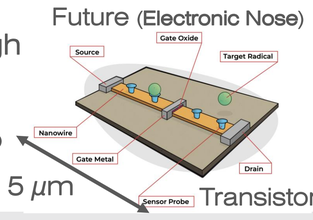
Detection of Radicals lead to better monitoring of air quality

Detection of Radicals
- Is complex & expensive
- Only a few spectroscopy based facilities worldwide

Anticipated Breakthrough
- Junctionless transistor based electronic sensors
- Easy to use and cheap

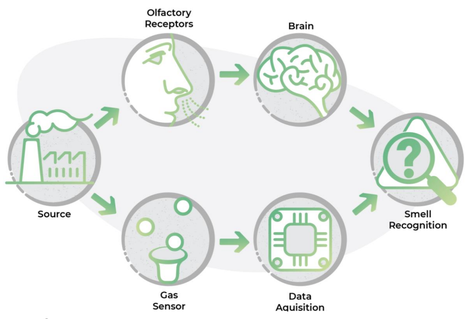
Now (Spectrometer)

Future (Electronic Nose)



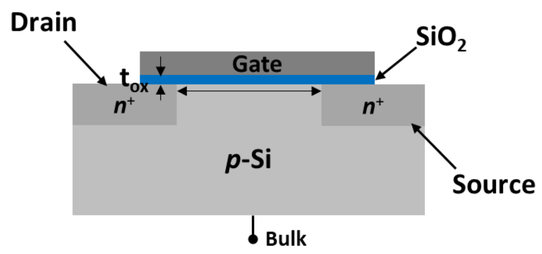
Transistor based

Human vs Electronic Nose

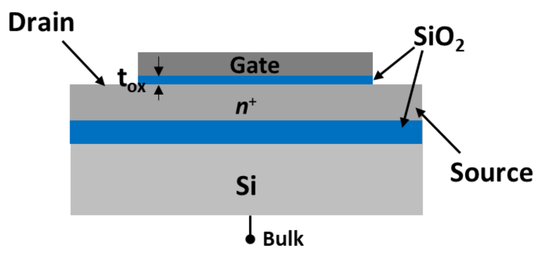


I. JUNCTIONLESS NANOWIRE TRANSISTOR (JNT)

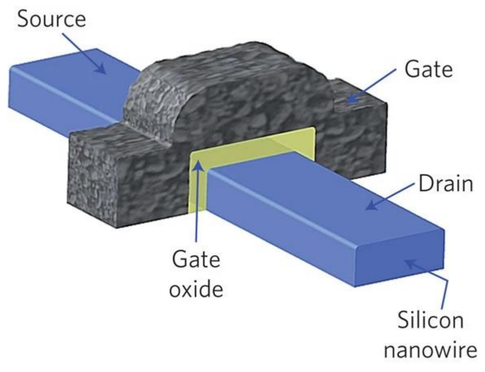
JNT has:
- Either n- or p-type doping and thus no ultra-steep doping profile
- Simplified fabrication process
- Nanoscale dimensions with high surface-to-volume ratio: ideal for sensing.



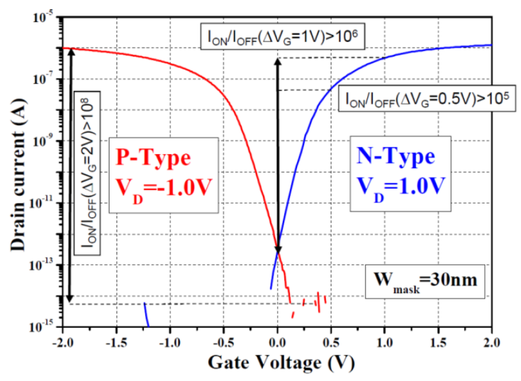
Conventional MOSFET



JNT



3D Schematic

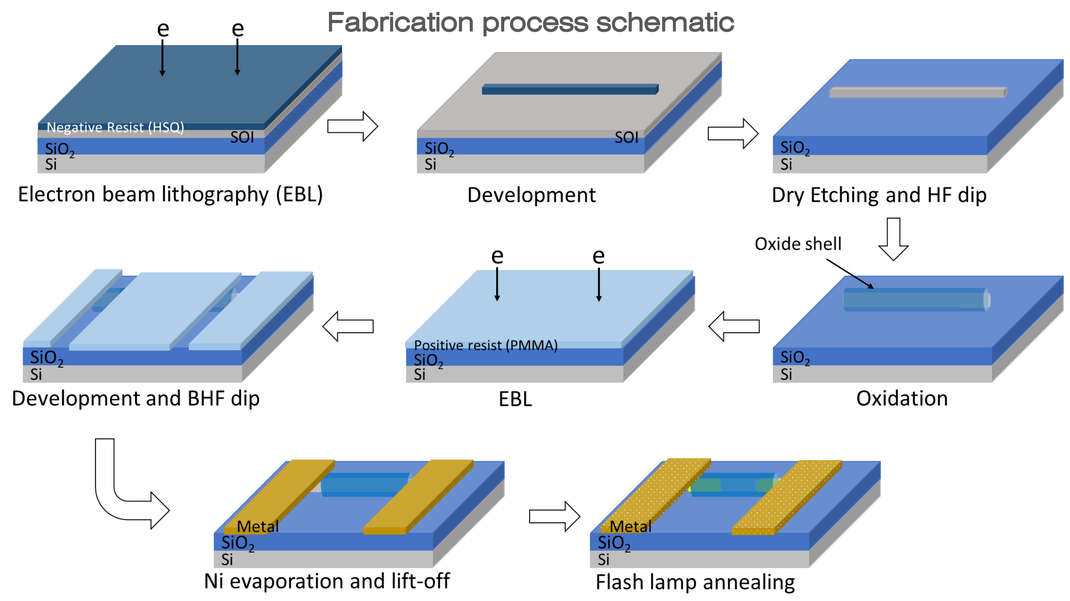


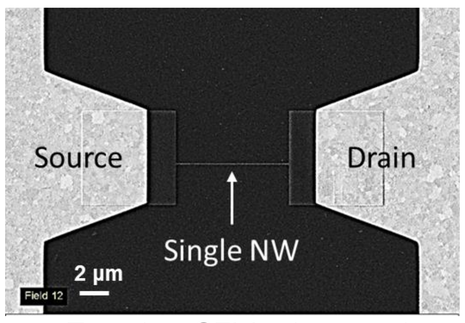
Transfer Characteristics

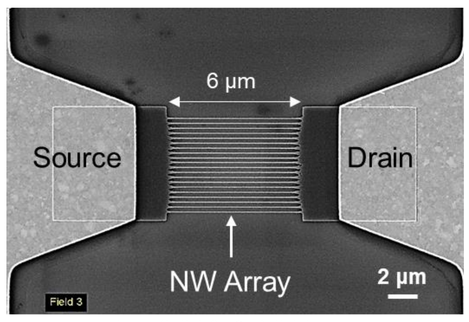
Colinge, Jean-Pierre, et al. Nature nanotechnology 5.3 (2010).

II. FABRICATION PROCESS

Highly phosphorous doped silicon-on-insulator substrates used.





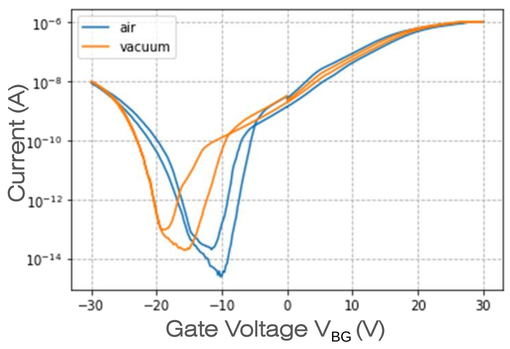


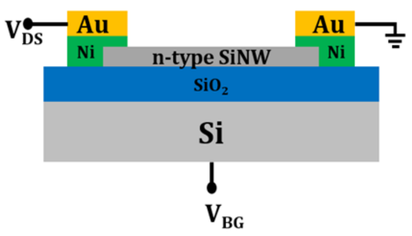
Top-view SEM micrographs: single nanowire (NW) & NW array

III. ELECTRICAL CHARACTERIZATION

Transfer characteristics of different devices in ambient (air) and vacuum conditions

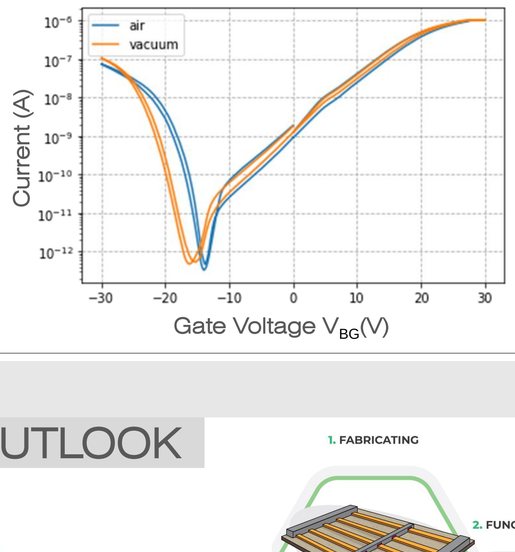
Single nanowire (NW) based device

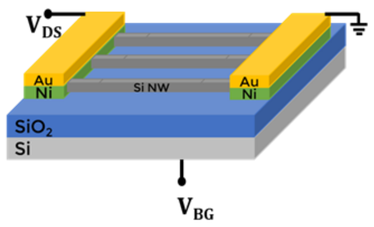




- Ambipolar characteristics
- Dominant n-conductance
- Characteristic shift in transfer curves of vacuum and air

NW array based device

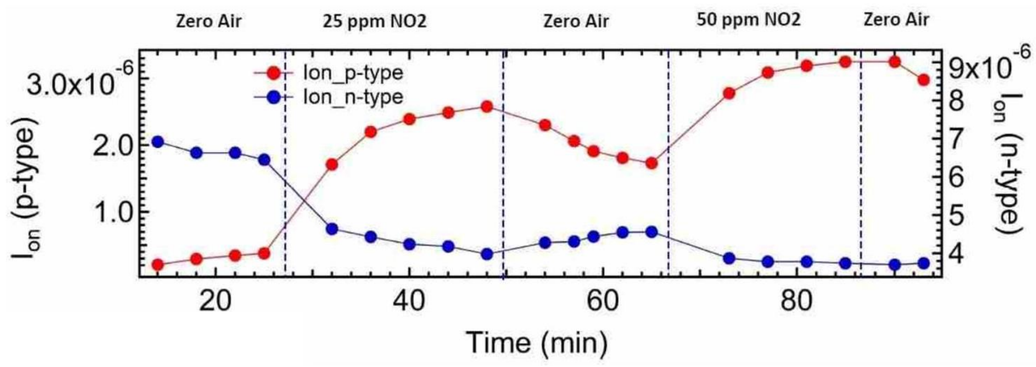




- 20 NWs in an array
- Higher on-currents than the single NW
- Better for sensing application

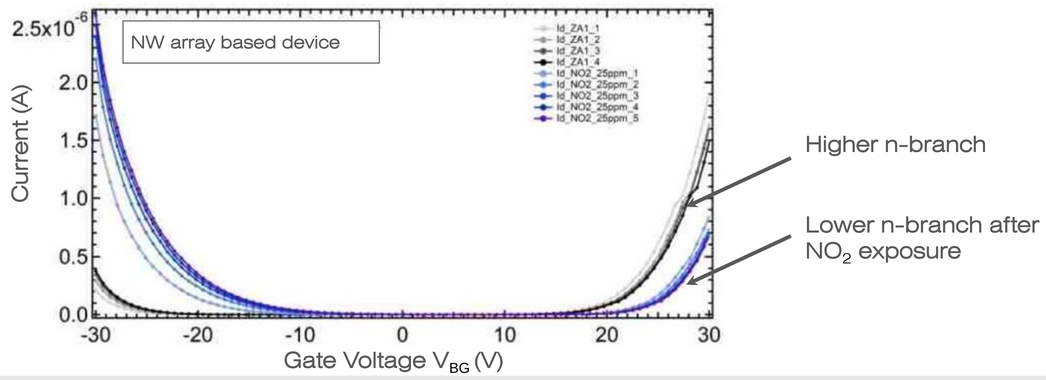
IV. INITIAL SENSING EXPERIMENTS

Change in electron (n) and hole (p) current at different concentration of NO_2 gas:



- NO_2 is a strong oxidizing gas and acts as an electron acceptor
- Exposure of nanowires to NO_2 leads to an increase in hole current and decrease in electron current.

Transfer characteristics:



OUTLOOK

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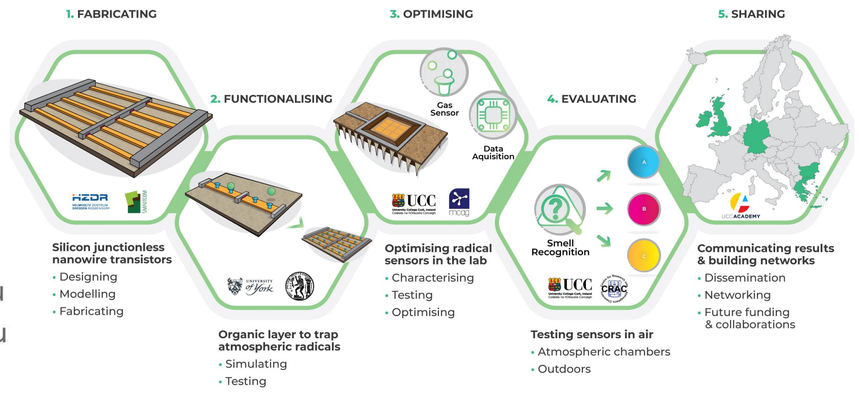

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