Wearable gas sensors

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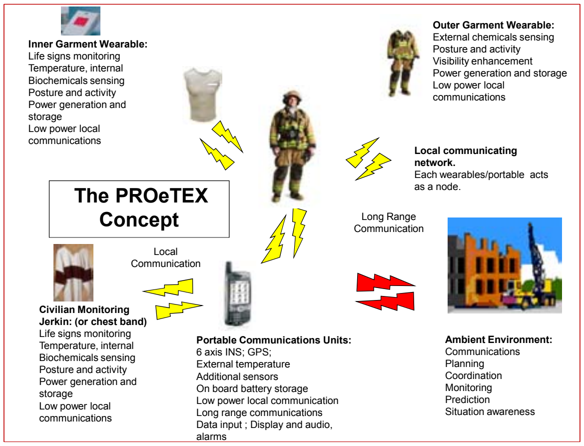
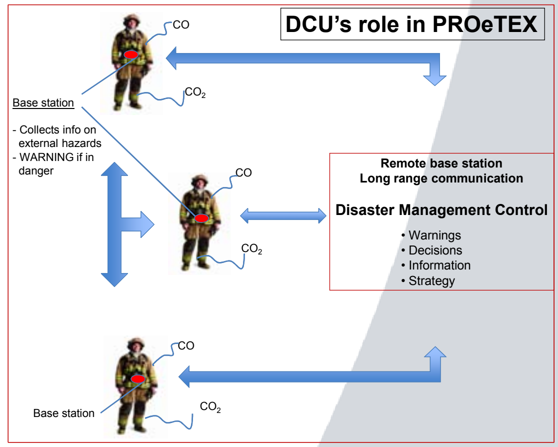
ABSTRACT. Wearable sensing applications have attracted much attention in recent years. The aim of the FP6 funded Proetex project is improving safety and efficiency of emergency personnel by developing integrated wearable sensor systems. This paper describes recent developments in the integration of sensing platforms into wearables for the continuous monitoring of environmentally harmful gases surrounding emergency personnel. Low-power miniature CO and CO_2 sensors have been successfully integrated in a jacket collar and boot worn by emergency personnel. These sensors need to provide information about the level of gas in the surrounding environment without obstructing the activities of the wearer. This has been achieved by integrating special pockets on the jacket and boot of fire-fighters. Each sensor is attached to a sensing module for signal accommodation and data transfer. The sensor performance has been evaluated by simulation of real-life situations.

These wearable gas sensors will dramatically improve personnel awareness of potential hazard and can function as a personal warning system. In this way, fire-fighter's jacket and boot not only protect the wearer, but have a second function of providing valuable information on external hazards.



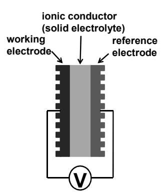
Advanced E-Textile systems can bring together sensors, connections, transmission systems, power management. The emergency disaster personnel smart garments will progressively enhance and integrate such textile systems to enable the following functions:

- Continuous monitoring of life signs (biopotentials, breathing movement, cardiac sounds);
- Continuous monitoring biosensors (sweat, dehydration, electrolytes, stress indicators, O_2, CO);
- Pose and activity monitoring;
- Low power local wireless communications, including integrated textile antennae;
- Internal temperature monitoring using textile sensors;
- External chemical detection, including toxic gases and vapors;
- Power generation - photovoltaic and thermoelectric and energy storage;
- Longer term e-textile technologies including further sensors, light emission and logic on fibre.

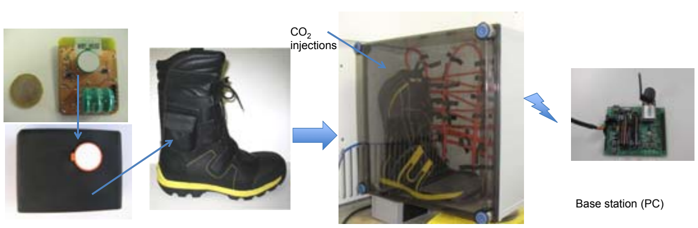


CO_2 sensing

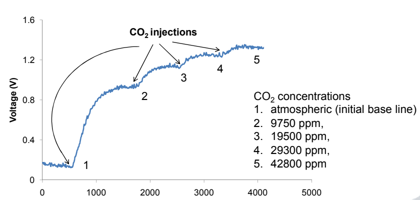
- Potentiomentric sensor
- Sensor integrated into a boot pocket
- Wireless transmission using Zigbee



Principle of a Potentiometric Sensor for Gases The signal is measured as the potential difference (voltage) between the working electrode and the reference electrode. The working electrode's potential depends on the concentration of the CO_2 in the gas phase



Wireless sensing module — Firefighter's boot — Testing chamber — Base station (PC)



Wirelessly transmitted signal from CO_2 sensor calibration (range atmospheric to 42800 ppm CO_2). Sensor was enclosed in an airtight chamber and CO_2 was injected.

CO sensing

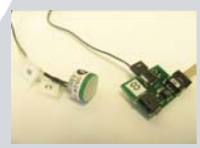
- Amperometric sensor
- Sensor integrated into a jacket collar

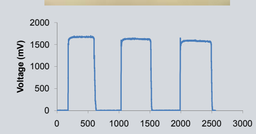
Principle of a Amperometric Sensor for Gases Carbon monoxide is oxidized at one electrode to carbon dioxide whilst oxygen is consumed at the other electrode. In an electrochemical cell selective to CO, the current that flows between the two electrodes, is proportional to the amount of CO present

Working electrode (anode): $2CO + 2H_2O \rightarrow 2CO_2 + 4e^- + 4H^+$

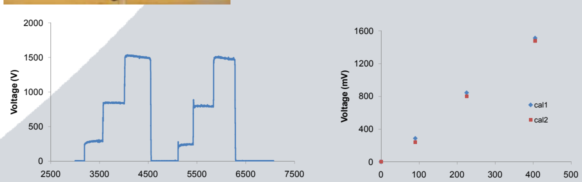
Counter electrode (cathode) $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

Overall react. $2CO + O_2 \rightarrow 2CO_2$





CO Sensors response to three single CO injections, each resulting in CO concentration of 405 ppm



Raw data and calibration curves from two CO sensor calibrations in concentration range: 0 ppm, 90 ppm, 225 ppm, and 405 ppm.

FUTURE ACTIONS

- Full integration of CO/CO_2 sensors into the garment
- Wireless transmission: communication of on-body base station and the remote station
- Evaluation of prototypes in laboratory conditions
- Evaluation of prototypes in-field conditions

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