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Extended Abstract

Nanostructured Chemoresistive Sensors for Oncological Screening: Preliminary Study with Single Sensor Approach on Human Blood Samples

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Introduction

The demand for reliable devices to detect tumor biomarkers in human body is constantly increasing. The reasons behind that lays on the advantage of early intervention on pathologies, allowing a greater chance of healing and survival for the patient, compared to taking action in the malignant state of a pathology not diagnosed in time. Consequentially, also the expenses for the National Health Systems drop consistently while the efficiency of intervention form physicians and surgeons increases, having a reduction on the malignant and terminal cases. Chemoresistive semiconductor sensors, fast responding devices commonly used for pollution and alimentary screening, can be the brand new choice as sensing units for medical devices aimed to this kind of approach, as multiple studies from the team proved their reliability for screening applications on different organic samples [1–6]. Four different sensors have been tested on a collection of blood samples, both from healthy and tumor affected individuals (colorectal and gastric cancer) ranging between 21 and 91 years of age, and the responses compared to recognize recurrent patterns from which the two populations could be distinguished. The trial protocol and the informed consent form for this research were presented, accepted and retrospectively registered from the Ethical Committee of the District of Ferrara, with trial number 170484, on 13 July 2017.

Application and Results

The following sensors have been used for the detection of the markers, emanated from human blood samples kept at room temperature:

- TiTaV—composed by titanium, tantalum and vanadium oxides
- STN—composed by tin, titanium and niobium oxides
- ST 25 650 +1%Au—composed by tin oxides and titanium and gold
- W11—composed by tungsten oxide

Each sensor was put to his best working temperature, defined by laboratory tests on the tumor markers previously studied, chosen from literature [1–3]. The responses are defined as the average value between three output voltages measured by the sensor from the same sample, as shown in the following formula:

$$R = \frac{\frac{V_{sensA}}{V_{0A}} + \frac{V_{sensB}}{V_{0B}} + \frac{V_{sensC}}{V_{0C}}}{3}$$

The volatile compounds exhaled from the 7 mL volume of blood were carried by the flow of filtered environmental air (to avoid contaminations and moist alteration) through the sensor chambers, where they reacted with the semiconductor film and

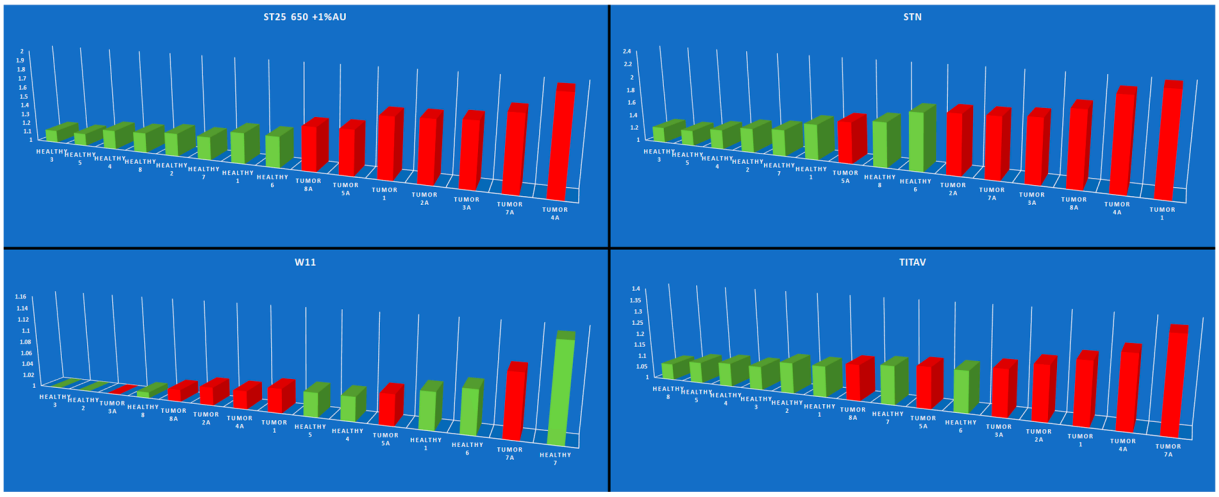

Figure 1. Tests results from ST25 650 +1%Au, STN, W11 and TiTaV on multiple blood samples.

As shown in Figure 1 from our results, three out of four sensors showed a recognizable trend, correlating the amplitude of the response with the markers of oncological interest, even if the responses were quantitatively smaller compared to other researches underwent in the past. The team is now gathering further data to increase the statistic pool and try PCA [6] and machine learning approach as in other studies, in order to define if these sensors are good choices for setting an array as sensitive core for a post-screening device, aimed to give fast responses from simple blood sampling for the follow up of patients that needed surgeries to heal from colorectal malignant neoplasms.

References

1. Zonta, G.; Fabbri, B.; Giberti, A.; Guidi, V.; Landini, N.; Malagù, C. Detection of Colorectal Cancer Biomarkers in the Presence of Interfering Gases. *Sens. Actuat. B* **2014**, *87*, 596–599.
2. Malagù, C.; Fabbri, B.; Gherardi, S.; Giberti, A.; Guidi, V.; Landini, N.; Zonta; G. Chemoresistive Gas Sensors for the Detection of Colorectal Cancer Biomarkers. *Sensors* **2014**, *14*, 18982–18992; doi:10.3990/s141018982.
3. Malagù, C.; Landini, N. Simulation of Intestinal Gaseous Environment in Order to Verify the Capability of Nanostructured Chemoresistive Sensors to Detect Colorectal Tumor Markers (Benzene, 1-Iodo-Nonane, Decanal). *J. Mol. Biomark Diagn.* **2015**, S2:012. doi:10.4172/2155-9929.S2-012.
4. Zonta, G.; Anania, G.; Fabbri, B.; Gaiardo, A.; Gherardi, S.; Giberti, A.; Landini, N.; Malagu, C.; Scagliarini, L.; Guidi, V. Preventive screening of colorectal cancer with a device based on chemoresistive sensors. *Sens. Actuat. B* **2017**, *238*, 1098–1101.
5. Zonta, G.; Anania, G.; Feo, C.; Gaiardo, A.; Gherardi, S.; Giberti, A.; Guidi, V.; Landini, N.; Palmonari, C.; Ricci, L.; de Togni, A.; Malagù, C. Use of gas sensors and FOBT for the early detection of colorectal cancer", *Sens. Actuat. B: Chem.* **2018**, *262*, 884–891.

6. Landini, N.; Anania, G.; Fabbri, B.; Gaiardo, A.; Gherardi, S.; Guidi, V.; Rispoli, G.; Scagliarini, L.; Malagù, G.Z.C. Neoplasms and metastasis detection in human blood exhalations with a device composed by nanostructured sensors. *Sens. Actuat. B: Chem.* **2018**, *271*, 203–214.