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Design of a multipurpose nano-enabled implantable device for personalized medicine

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This paper describes an innovative nano-enabled implantable device for in-vivo biomarkers monitoring that could be suitable for customized theranostics applications. Findings suggest that cross-cutting Key Enabling Technologies (KETs), i.e. nanotechnology, biotechnology, micro & nanoelectronics and advanced materials, could boost the development of new nano-enabled medical devices, using biocompatible materials, and embedding reliable and targeted biosensors. A key issue introduced by the authors is that the general architecture of the medical device could be programmable in the direction of personalized medical applications.

The current interaction between medicine and technology permits the development of new diagnostic devices to detect or monitor pathogens, ions, diseases, etc. Doubtless, the integration of rapid advances in areas such as microelectronics, microfluidics, microsensors and biocompatible materials entails the availability of implantable biodevices for continuous monitoring or event detectors that carry out faster and cheaper clinical tasks than when these are done by standard methods. Implantable devices have already been used in millions of patients [1]. Benefits of these approaches include improved care and quality of life for millions of patients [2]. Implantable sensor networks can facilitate an early detection of emergency conditions and diseases in patients at risk, [3] comprising physical, physiological, psychological, cognitive, and behavioral processes, by reaching inaccessible environments in a reduced response time [4].

It is in this context that we present an integrated front-end architecture for in-vivo customized detection. A new and challenging scenario defined as the pervasive system is focused on the development of systems capable of monitoring human bodily functions and to transmit the resultant data for a clinical patient's monitoring [5]. Thanks to this approach, it could be possible to monitor patients anywhere and at all times with important impact on their quality of healthcare preventing the worst scenarios for the patients as well as improving the wellbeing and continuing activity of the whole population. The possibility of controlling how a therapy is working, detecting symptoms, and knowing how the disease is progressing will improve the personalized medical care known as theranostics. Patients at risk because of their genetic background, chronically ill or elderly people will be monitored outside of and beyond visits to the hospital or at the surgery. Here, the significant advantage is to monitor patients in their routine daily activities, as traditional clinical monitoring would be replaced by continuous and remote monitoring [6], which could have a great impact on patients' quality of life and could reduce the cost of the overall healthcare system [7]. Amongst all the medical applications and diseases, findings suggest that chronic illness deserves special attention [8], particularly in the case of cardiovascular illness [9].

Theranostics covers a wide range of applications as health interventions with drugs (pharmacogenomics), nutrition (nutrigenomics) and vaccines (vaccinomics), as well as diagnostics for human diseases [10]. Implantable medical devices are widely used for therapeutic [4] or life-saving purposes such as cardiac arrhythmia, diabetes, and Parkinson's disease [11]. Applications include drug delivery systems, pacemakers, implantable cardiac defibrillators (ICDs) and Neurostimulators [1]. Some real-time monitoring applications include physiological parameters like blood pressure, glucose levels and collecting data for further analysis [4]. These devices often contain electronic components that perform increasingly sophisticated sensing, computation, and actuation, in many cases without any patient interaction [1] as in the applications mentioned above, performing complex analyses with sophisticated decision-making capabilities. They are capable of storing detailed personal medical information, and communicate automatically, remotely, and wirelessly [2]. Implanted nano-enabled biosensors form a wireless network that can be used for data aggregation and data dissemination applications [4].

The system introduced in this paper is conceived to be implanted under the human skin. The powering and communication between this device and an external primary transmitter are based on an inductive link [12]. The architecture presented is designed with two different approaches: defining a true/false alarm system based on either amperometrics or impedance into a grid of nano-biosensors that could permit the monitoring of several diseases by in-vivo analysis of the corresponding biomarkers.

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