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An Energy-Autonomous Biomedical IoT Platform Using Human Computer Ion-Coupled Energy Interaction for Next-Generation Diabetes Care

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Abstract

Design of experimental verification of an energy-autonomous biomedical IoT platform using human computer ion-coupled energy interaction (HCEI) enabling next-generation diabetes care is presented in this paper. By exploiting energy-efficient solid-state CMOS integrated electronics and solid-state bio fuel cells, energy-autonomous biomedical IoT platform with HCEI can be realized. This biomedical IoT platform has a potential for contributing development of next-generation diabetes care.

1. Introduction

Developments of solid-state devices and materials has contributed dramatical performance improvement of solid-state electronics especially CMOS integrated circuits. This performance improvement enables small-form-factor computing such as smartphones, mobile laptops, and so on. This downsizing of computers promotes interactions between human and computers.

Following this trend, the term of human-computer interaction (HCI) has been becoming more and more popular in these days. In HCI, humans and computers are interacted using five senses such as touch, taste, hearing, eyesight and smell. Existing HCI is usually based on the

In this paper, human computer energy interaction (HCEI) using ion-coupled energies for biomedical IoT application is discussed. By combining the energy-efficient solid-state CMOS integrated electronics and solid-state bio fuel cells, HCEI-based biomedical IoT platform can be feasible. In the following sections, concept, implementation, and prototyping has been introduced.

2. Biomedical IoT with human computer ion-coupled energy interaction (HCEI)

Fig. 1 shows the conceptual diagram of the proposed biomedical IoT platform with HCEI. HCEI-based IoT are attached to skin while it gets energy and biomolecule concentration information from the human metabolism solutions such as sweat, tear, saliva, and so on. The obtained information is transferred to mobile devices. By associating with big-data analysis employing artificial intelligence (AI), our daily life can be dramatically improved.

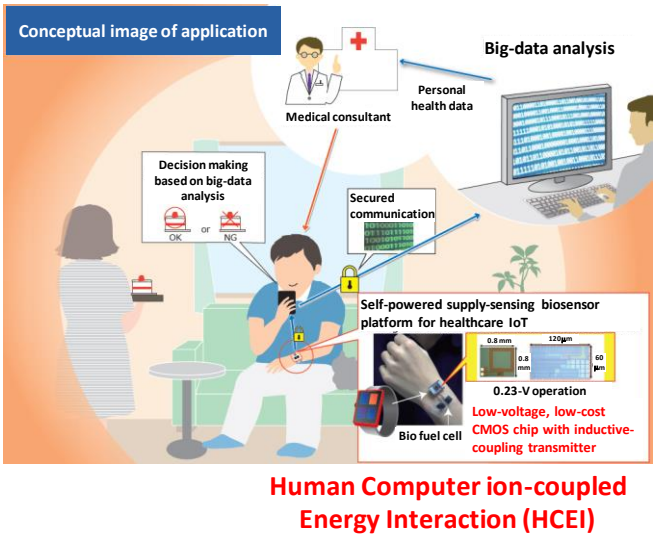

Fig. 1. Conceptual diagram of the proposed biomedical IoT platform with HCEI [1-2].

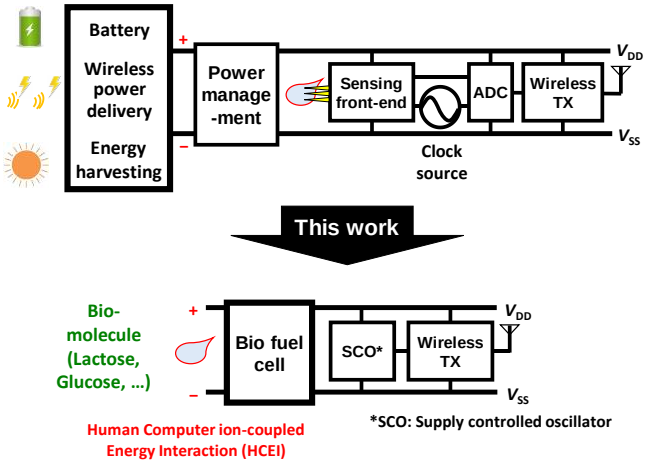

Fig. 2. Circuit architectures of the conventional one and proposed biomedical IoT platform with HCEI [2].

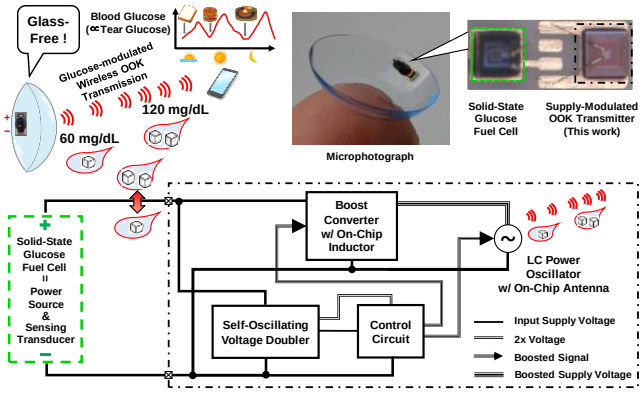

Fig. 3 Proposed biomedical IoT platform with HCEI for enabling glasses-free continuous glucose monitoring contact lens [1].

Fig. 2 show the circuit architectures of the conventional one and the proposed biomedical IoT platform with HCEI. It consists of three parts: the bio fuel cells, supply controlled oscillator (SCO), and a wireless transmitter. The most important different point from the conventional topologies is elimination of the power management circuits, clock sources, and ADCs, which allows dramatical cost and energy reduction.

For demonstrating the effectiveness of the proposed approach, we have developed some prototypes. First, energy-autonomous fructose monitoring was demonstrated [2]. Second, energy-autonomous lactate monitoring with temperature monitoring was demonstrated [3]. These prototype employs current-driven inductive-coupling links [4] for low-voltage operation.

3. HCEI-based biomedical IoT for diabetes care applications and future works

Fig. 3 shows the prototype of HCEI-based biomedical IoT for diabetes care applications which enables glasses-free continuous glucose monitoring contact lens. The existing RFID-based glucose-monitoring contact lens [5] requires wearing smart glasses for wireless power delivery. While, the proposed technique get energy from tear glucose, which allows glasses-free application.

The introduction of biofuel cell also enables elimination of electrochemical sensing front end. Since electrochemical sensing front end requires power-hungry analog-based potentiostat, this elimination contributes dramatical power reduction. In fact, we have successfully reduced power from 3 μW [5] to 1.9 nW [1].

Now, we are trying to improve the performance for practical application. Enhancement of output power of the glucose fuel cell is now investigation [6-8]. By taking advantage of always-on capability, introduction of AI-based glucose level prediction employing recurrent neural network [9] is being developed.

Additionally, HCEI-based biomedical IoTs have potential for further performance improvement. By associating with other CMOS-based biosensing such as cancer cell counting [10], CTC/exosome deterction [11], DNA detection [12-13], they will be more beneficial for our daily life.

4. Conclusion

An energy-autonomous biomedical IoT platform using human computer ion-coupled energy interaction has been presented. It is expected that the proposed biomedical IoT will contribute improvement of next-generation diabetes care and our QoL.

Acknowledgements

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