【Grant-in-Aid for Transformative Research Areas（B）】

Functional Evolution in Electronics

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Project Information	Project Number : 24B401　　Project Period (FY) : 2024-2026 Keywords : Functional evolution, Electronic materials, Artificial multicellular system, Bio-electronic bonding, Bio hybrid devices

Purpose and Background of the Research

●Outline of the Research

We propose ”Functional evolution in electronics" which is defined as a new concept that extends the process of evolution to materials and devices. This device concept imitates nature which acquires functions and evolves by autonomously optimizing itself, for example, by changing to the optimal structure in response to the environment and circumstances. Based on this definition, this research aims to develop a concept of electronics that can be created without a blueprint based on the principle of self-ordering, rather than the conventional concept of electronics that is constructed based on a blueprint. As living organisms have evolved by adapting to their environment, electronic devices would change and evolve without a blueprint in response to the environment and circumstances. In contrast, conventional electronic devices have been designed with structures and functions that meet their purposes and specifications, and this has led to the most advanced technologies of the modern era. In the current situation where many issues exist, such as the limits of transistor size, resource depletion, and increasing power consumption, breakthroughs to solve these issues are essential in this field of electronic devices. If the adaptability and flexible response of living organisms can be applied to electronic devices, we can expect to reduce the number of devices to be fabricated, thereby reducing materials and power consumption, and creating new functions that could not be realized before, through device changes in response to the environment. The academic creation and application of devices with evolving functions is the goal of this field of ”Functional evolution”. This science will be realized through the fusion and reorganization of research results from research projects aimed at solving individual problems in the scenario shown in Fig. 1.

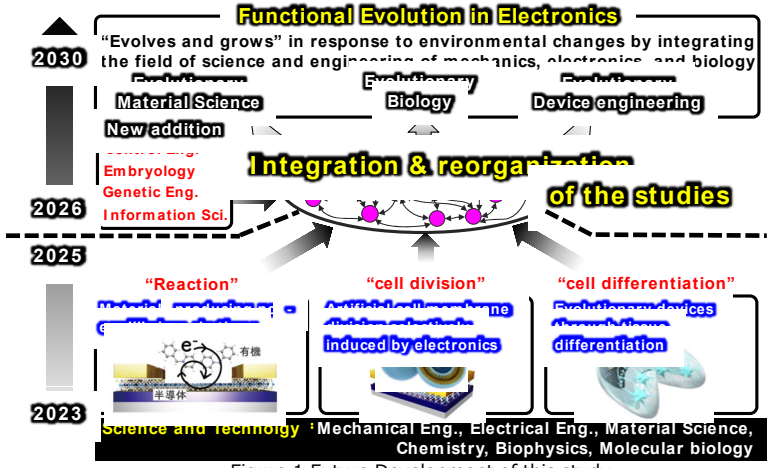

Figure 1 Future Development of this study

●Why we decided to conduct this study:

The members, who have been working different fields, came to discuss of creating a research concept “evolving electronics”. The members specialize in mechanical engineering, electronics, materials science, chemistry, biophysics, and molecular biology, and have met new research collaborators who are familiar with biological evolution and specialize in information science and intelligent material physics, as well as research collaborators who specialize in the formation and regulation of neurons and muscle tissue induced differentiation from human iPS cells. The cooperation with researchers in these different fields led to new opportunities. The discussion with researchers in different fields convinced us that we could pursue a completely new form of bioengineering, ”functional evolution in electronics" and led to the establishment of this field of study.

Expected Research Achievements

Functional evolution in electronics is a system of knowledge of "evolving artifacts" for the creation of the above-mentioned science and engineering. The system consists of "Evolutionary Materials Science," "Evolutionary Biology," and "Evolutionary Device Engineering”. Evolutionary materials science focuses on the study of how to realize the mechanisms of living organisms with electronic materials. Evolutionary biology is the creation of science to control movement by freely changing and training movement of cells. Evolutionary Device Engineering is the design of electronic circuits that can freely change in response to environmental stimuli, etc., and the creation of functions that meet the needs of the application. The creation of these studies will realize the functional evolution of electronics as shown in Figure 2. Conventional electronics is considered the 0th generation, which is built based on a "blueprint" and does not undergo further change or evolution. In contrast, in the first generation of this field, materials move and change in a self-ordered manner in response to circumstances to assemble microscopic electronic elements. In the second generation, macroscopic electronic circuits are created by fusing the first-generation elements with artificial cell membranes that think, divide, and grow on their own. In the third generation, cells are integrated three-dimensionally to form tissues, which are programmed by the environment to spontaneously divide and differentiate to create devices that express functions suited to their purpose. In the future, this will further evolve into an autonomous system that can be constructed without a "blueprint" in accordance with the principle of self-control (fourth generation). By applying the technological foundations of bioelectronics that have been researched and developed around the world, the project will expand into a completely different dimension of research and development in an unexplored area.

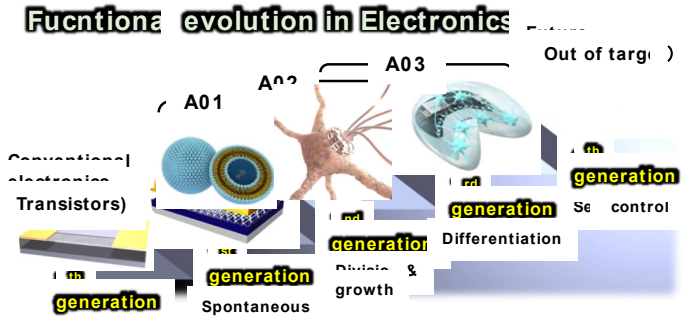

Figure 2 This study vision of the future

Homepage Address, etc.	This research area HP http://evolutionelectronics.jp/