【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅰ)

Title of Project：Development of dopant atom devices based on silicon nanostructures

Michiharu Tabe
（Shizuoka University, Research Institute of Electronics, Professor）

Research Area：Engineering
Keyword：electronic device/integrated circuit, silicon, dopant, atom device

【Purpose and Background of the Research】

Since the invention of the transistor, silicon technology has been developed using dopant impurity atoms. The statistical effect of many dopants has worked effectively until now, but recently device downscaling reached the point where the number of dopants and fluctuations in their arrangement significantly affect device characteristics. This is a fundamental problem related to the principle of operation of semiconductor devices and drastic solution is required. On the other hand, several groups, including ours, recently reported FETs with operation governed by individual dopants.

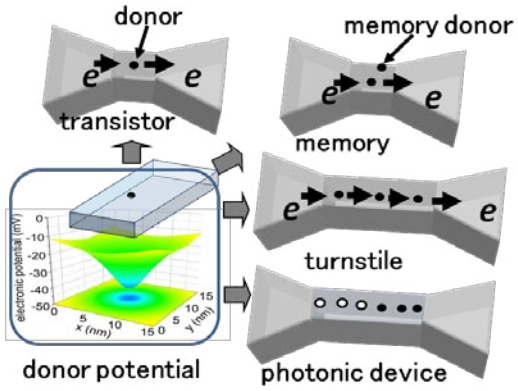
This research aims at the development of atom-level devices utilizing individual dopant atoms. A transistor using only one dopant atom is at the basis, and devices containing 2 or more dopant atoms can allow the development of memory, single-electron transfer, or photonic devices. In parallel, comprehensive research on single dopant implantation, detection technology, and first-principles calculations of nano-physical properties of dopants will form the grounds of dopant atom device engineering.

【Research Methods】

In this research project, significant advances will be pursued in dopant atom devices, high-accuracy dopant implantation, dopant position detection technology, and first-principles theoretical analysis. In particular, focus will be on single dopant atom transistors, although memory, single-electron transfer, and photon detection devices will also be studied for future integration.

【Expected Research Achievements and Scientific Significance】

The purpose of this research project is not the extension of technologies used so far, but the construction and study of a technical system for atomic devices. Some researchers in Australia, Europe and United States are working on quantum computers, utilizing the spin of phosphorus, but worldwide there are no other research projects similar to ours. The atomic devices produced from this research will produce a new group of extremely-small and low power devices, including single-electron FETs, single electron memory, single electron transfer devices, and photonic devices for optical information processing. Furthermore, we aim at room temperature operation of dopant atom devices for practical implementation. Thereafter, integration for industrial applications is expected with nanoelectronics and nanophotonics.



【Publications Relevant to the Project】

- M. Tabe, D. Moraru, M. Ligowski, M. Anwar, R. Jablonski, Y. Ono and T. Mizuno "Single-electron transport through single dopants in a dopant-rich environment", ***Phys. Rev. Lett.***, **105**, pp.016803-1-4 (2010).
- E. Hamid, D. Moraru, J. C. Tarido, S. Miki, T. Mizuno and M. Tabe, "Single-electron transfer between two donors in nanoscale thin silicon-on-insulator field-effect transistors", ***Appl. Phys. Lett.***, **97**, pp.262101-1-3 (2010).

【Term of Project】 FY2011-2015

【Budget Allocation】 161,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.rie.shizuoka.ac.jp/~nanohome
romtabe@rie.shizuoka.ac.jp