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

Title of Project： Yuragi Electronics Inspired by Living Bodies

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Research Area：Oxide Electronics, Bioelectronics
Keyword：Spinglass, Relaxor, Yuragi, Stochastic resonance

【Purpose and Background of the Research】

A general characteristic of a computer is its generous use of power in comparison to thermal noise, which suppresses the error rate and allows high-speed logic calculation. But such high speed processing is accompanied by enormous electric power consumption. In addition, software that stipulates the operation is separated from the hardware, leaving the system vulnerable in a fluctuating environment. Biological information processing, on the other hand, which uses thermal (organic) "Yuragi" to operate stochastically, is characterized by its energy consumption level that is the same as thermal noise; speed being sacrificed. When elements governed by stochastic "Yuragi" are systematized, one can produce a brain-like information processing system that is indigenous to biological systems. For example, while individual neuron cells are influenced by noise, as a group they are able to create a highly reliable information processing system. Moreover, they are able to create new algorithms independently, leading to a robust system even in a fluctuating environment.

This study`s originality and significance stems from the application of biological "Yuragi" based information processing towards the creation of novel devices that are equipped with biological functions, represented by brain functions.

【Research Methods】

Two types of memory materials will be mainly studied to mimetic a bio "Yuragi" system. The one is spin glass with spin fluctuation and relaxor with dipole fluctuation. As a starting point, spin glass related material will be mainly discussed. From our former researches, some spinel type ferrites have shown spin glass behavior at room temperature as a preliminary results. By using these materials, electrical analysis will be performed whether these materials show good properties to inspire a bio "Yuragi" function. For example, substitution of Mg^{2+}, Al^{3+}, Ru^{3+}, $Ti^{3+,4+}$ for spinel - Fe_3O_4. And artificial crystallographic control will be performed by a Laser MBE technique with sequencing of 0% to 100% ordered structures. The artificial superlattices are deposited on $SrTiO_3$, Al_2O_3 substrates and show an epitaxial growth.

We will replace one layer of Magnetic metal layers by spin glass layer of MRAM based memory devices. In a period of integration step, we will collaborate with some private companies to fabricate micro-structured spin tunneling junctions of magnetic layer (100nm)／Insulator（1～2nm）／spin glass layer. Furthermore, to realize an ideal information processing device, we will combine our devices described above with optical read/write system. Properties of light induced magnetization are key function.

【Expected Research Achievements and Scientific Significance】

By considering organic information processing dynamics as a summation of kinetic energy of particles in a meta-stable potential, and by modeling it with ferromagnetic and ferroelectric materials, we may be able to realize biological information processing systems by utilizing "Stochastically Resonance Phenomena". In other words, a new type of electronics, one which is systematically stable even though its meta-stable potential well depth is comparable to the energy of "Yuragi" , and one which is able to adapt to environmental change, can be expected.

【Publications Relevant to the Project】

・Science, 280(1998)1064
・Appl.Phys.Lett. 78 (2001) 512 & 76 (2000) 1179
・Phys.Rev.E, 79 (2009) 021902
・Appl.Phys.Express. 1 (2008) 088002.

【Term of Project】 FY2012-2016

【Budget Allocation】 123,400 Thousand Yen

【Homepage Address and Other Contact Information】

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