Title of Project : All Solid State Superconducting System for Neutron Radiography with One Million Pixels and Submicron Resolution

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Research Area : Superconductivity, Nanostructured superconductors

Keyword : neutron, radiography, MgB_2 superconductor, single flux quantum device

【Purpose and Background of the Research】

Neutron radiograph is an essential tool to lead progresses in science and industry in the 21^{st} century. Two unique technologies will be applied to fulfill prerequisites (submicron resolution, one million pixels, high frame rate, and all solid-state system). A superconducting nanowire array of MgB_2 is used to recover a change in kinetic inductance ΔL_K of the nanowire induced by reaction heat between neutron and ^{10}B. This enables larger pixel size based on the achievement of submicron resolution and two-dimensional array of pixels. Maximum likelihood circuit of single flux quantum device (SFQ) plays a crucial role to detect ΔL_K at extreme sensitivity, and to process acquired data at high rate with ultra low power consumption.

【Research Methods】

High-quality MgB_2 epitaxial films, fabrication technique of MgB_2 nanowire, and a large-scale NxN array of superconducting nanowires will be developed. As shown in Fig. 1, two systems of linear arrays are installed at right angles. Nuclear reaction between neutron and ^{10}B yields alpha- and lithium-particle emissions in the opposite direction. Two particles are simultaneously counted by X-direction and Y-direction arrays. The principle to detect a signal is to see a change in kinetic inductance at 4 K. The 1-ns high speed of MgB_2 detector requires a 100-GHz SFQ circuit.

Ultimately, we intend to demonstrate our evolutional all-solid-state system by neutron irradiation at J-PARC or JRR-3M.

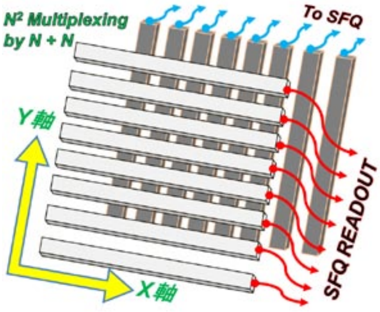

Fig. 1. Multiplexing of MgB_2 detectors consisting of 1D array of N detectors to X- and Y- directions for simultaneous counting of the event.

【Expected Research Achievements and Scientific Significance】

Neutron radiography is a powerful method for revealing the positions of light elements in materials and the observation of magnetic structures. A large number of pixels of submicron spatial resolution enable us to utilize a spintronics tool using spin-polarized neutrons. For example, dynamics of water as a byproduct of fuel cells can be observed as a fast animation with high spatial resolution. Our system will influence even other fields such as agriculture and biology.

【Publications Relevant to the Project】

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【Term of Project】 FY2011-2015

【Budget Allocation】 165,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.pe.osakafu-u.ac.jp/pe1/