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, MgB₂ 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 21st 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 MgB₂ is used to recover a change in kinetic inductance \(\Delta L\) 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 \(\Delta L\) at extreme sensitivity, and to process acquired data at high rate with ultra low power consumption.

Research Methods

High-quality MgB₂ epitaxial films, fabrication technique of MgB₂ 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 MgB₂ 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.

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


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/