Project No. : 15002 Core Institution in Japan: University of Tsukuba	

JSPS Core-to-Core Program -Strategic Research Networks- FY2007 Research Report

Project No.	15002
Research Theme	Nanoscience and Engineering in Supercondutivity
Duration of Project	April 1, 2006～March 31, 2009
Core Institution in Japan	University of Tsukuba

Implementing Organizations

Country	Japan
Core Institution	University of Tsukuba
Co-Chair (name and title)	Professor Kazuo Kadowaki
Number of Cooperating Institutions	14
Cooperating Institutions	Keio University, Tohoku University, University of Tokyo, Tokyo Institute of Technology, National Institute for Materials Science, Japan Atomic Energy Agency, RIKEN, Hitachi Advanced Research Laboratory, NEC ,Kyushu University,Hirosaki University,Utsunomiya University,Tokyo University of Science,Nagoya University

Country	EU
Core Institution	Katholieke Universiteit Leuven
Co-Chair (name and title)	Professor Victor Moshchalkov
Number of Cooperating Institutions	18
Cooperating Institutions	University of Antwerp, CNRS-CRTBT, University of Bordeaux, Research Center Julich, University of Tubingen, University of Erlangen-Nurunberg, Walther Meissner Institute, University of Naple, Leiden University, University of twente, University of Madrid, Chalmers University of Technology, University de Geneve, ETH, University of Bath, University of Chambridge,Loughborough University,University College London
Matching Fund	about 100K Euro

Country	USA
Core Institution	Argonne National Laboratory
Co-Chair (name and title)	Dr. Wai -K. Kwok
Number of Cooperating Institutions	8
Cooperating Institutions	University of Notre Dame, Northern Illinois University, Texas A & M University, The University of Chicago, University of Illinois at Chicago, University of South Carolina, University of California at Davis, University of Illinois at Urbana-Champaign
Matching Fund	about 200kUS$

Result of Program Implementation

Superconducting phenomena exhibiting absolute zero resistance are extraordinary physical realization in metals, in which a macroscopic scale of quantum mechanical coherence develops as a result of strong electron-electron correlations. In order to understand the superconducting phenomena more deeply by utilizing the advanced nano-technology, quests for new superconducting phenomena associated with the quantum coherence and for superconductors with transition temperatures as high as room temperature, and researches of quantum computation, etc. will be pursued based on the fundamental materials science. With emphasis on the characteristics of the core institutions and in collaboration with core researchers internationally it is of our final goal to explore a new scientific and technological paradigm for the future scientific society in a quarter of century in advance.

We heve set up international collaborative research network organization between three partners over the world (Japan, EU and USA) on Nanoscience and Engineering in Superconductivity (NES) fully utilizing nano-enginnering techniques for preparing materials as well as for experimental techniques during past several years.

The following remarkable results have been obtained.

Achievements in FY2007 (Self Review)

We have made a continuous effort on the discovery of novel phenomena associated with the superconducting coherence and obtained interesting achievements being important for the applications. In the following we list only 4 items achieved in FY2007.

1. Direct observation of THz radiation: We have succeeded in detecting THz radiation from intrinsic Josephson junction system $Bi_2Sr_2CaCu_2O_{8+\delta}$ by meas of both bolometric and spectroscopic techniques. The emission mechanism is attributed to the coherent synchronized oscillation of the superconducting phase of intrinsic Josephson junctions similar to LASER.
2. Study of macroscopic quantum tunneling (MQT) phenomena using the intrinsic Josephson junction system $Bi_2Sr_2CaCu_2O_{8+\delta}$ artificially engineered into mesoscopic sizes. We have found a profoud extraordinary high crossover temperature T^* of the order of 4 K, which exceeds an order of magnitude and is in favor for the quantum phase devices operating at liquid Helium temperature.
3. We were successfully able to understand the mechanism of the BEC(Bose-Einstein condensation) phenomena using the Feshbach mechanism. This condensation mechanism can be applied to superconductivity.
4. We were able to synthesize a new superconductor $REFeAsO_{1-x}F_x$ ($0.1<x<0.3$, and RE=rare earth elements), whose T_c value is as high as 52 K. This non-cuprate superconductor will be most important material to be studied in coming years, because they may be a clue to solve the mechanism of high temperature superconductivity.

In addition to these scientific achievements, we organized the International Conefence, 5th International Symposium on the Intrinsic Josephson Effect in High Tc Superconductors, one domestic workshop, and 3 times informal meetings on the current developments of research in Nanoscience and Engineering in Superconductivity.

Future Plan (Measures toward Achieving Research Objectives)

Within the strategic research network organizaion between Japan, EU countries and USA, we plan to extend our researches to more focussed subjects of the currently important problems: THz generation using high T_c superconductor intrinsic Josephson junctions and the macroscopic quantum phenomena utilizing nanotechnology. The former one was originated from our study in Japan on the Josephson plasma resonance so that we intend to concentrate on this problem. The latter one is important in the sense of future information technology and quantum computations. Multi-stacking high T_c intrinsic Josephson junctions are considered as a most ideal candidate for these purposes. Furthermore, development of new materials with higher T_c is crucial. Room temperature superconductors are desired to be a target materials as an ultimate goal of our research. The recent discovery of novel superconductor $REFeAsO_{1-x}F_x$(RE=Rare Earth elements, $0.1<x<0.3$) is along with this trend. Both wide overviews of materials from point of view of Physics and Chemistry and detailed calculations based on the various models are needed for. By the time at the end of this program we hope to have a dramatic increase of the critical temperature towards room temperature or even beyond it.