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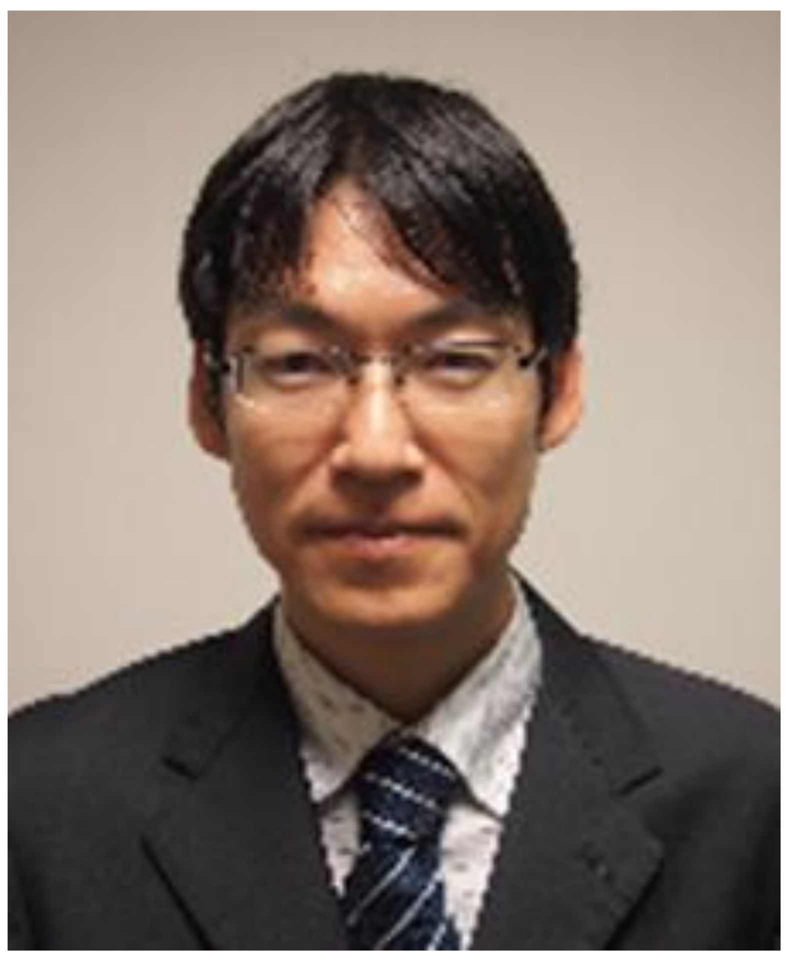
The Sir Martin Wood Prize Lecture

Creation of Functional Electronic Phases



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Biography

2001: B.S. Department of Applied Chemistry, The University of Tokyo

2003: M.S. Department of Advanced Materials Science, The University of Tokyo

2006: Ph.D. Department of Advanced Materials Science, The University of Tokyo

2006: Special Postdoctoral Researcher, RIKEN

2006-2014: Research Associate, Institute for Solid State Physics, The University of Tokyo

2014-present: Associate Professor, Department of Applied Physics, Nagoya University

SIR MARTIN WOOD PRIZE LECTURE

Dr. Yoshihiko Okamoto

Associate Professor, Department of Applied Physics, Nagoya University

Tuesday 28th May 2019 3pm
Martin Wood Lecture Theatre
Department of Physics
University of Oxford

Novel transition metal compounds with remarkable electronic properties, such as cuprate and iron-based superconductors, have opened up a new era of the condensed matter physics. In this talk, I will present the results of materials exploration of transition metal compounds using the crystal and electronic structure databases based on knowledge of solid state chemistry, toward the discovery of such electronic properties and functions. We developed various materials including high-performance thermoelectric materials, candidate nodal-line semimetals, superconductors, metal-insulator transition systems, and geometrically frustrated magnets. In this talk, I will focus on the former two systems.

1. One-dimensional telluride Ta_4SiTe_4 as a high performance thermoelectric material.

Thermoelectric cooling is a promising candidate for the next-generation of refrigeration technologies in replacing vapor compression cooling using gaseous refrigerants. However, there is currently no bulk material with a high enough performance to reach a practical level in the low temperature region. We found that Ta_4SiTe_4 and its substituted compounds show high thermoelectric performance at low temperature. Thermoelectric power of Ta_4SiTe_4 whisker crystals reaches S = -400 μV K^{-1} at 100-200 K, while maintaining low electrical resistivity of ρ ~ 2 mW cm. These S and ρ give a larger power factor of $P = S^2/\rho$ of 80 μW cm^{-1} K^{-2} than those in Bi_2Te_3-based practical materials at room temperature, indicating that Ta_4SiTe_4 is a promising candidate for the low temperature applications of thermoelectric cooling. This very large P is probably caused by the very small spin-orbit gap opening on the strongly one-dimensional electronic bands at the Fermi energy.

2. CaAgP and CaAgAs as a candidate nodal-line semimetal.

In recent years, Dirac and Weyl semimetals, which are zero-gap semiconductors with linear dispersion bands at the zero-gap points, have attracted broad interest as candidate systems for realizing topologically nontrivial states in bulk materials. In contrast, some systems are theoretically indicated to have a nodal line, where the linear dispersion bands cross on a line in the momentum space. We found that CaAgP and CaAgAs are promising candidates for the nodal-line semimetal. First principles calculation results indicate that the both compounds are ideal nodal-line semimetals, where the Dirac points form a ring at the Fermi energy. We synthesized polycrystalline samples and single crystals of CaAgP and CaAgAs and found that they have a ring-torus Fermi surface related to the nodal ring by physical property measurements of them.

Associate Professor Okamoto was awarded the Sir Martin Wood Prize at the Millennium Science Forum which took place in November 2018. The Millennium Science Forum was established in 1998 to promote scientific exchange between Britain and Japan and recognize the work of outstanding young Japanese researchers. The prize is named after Sir Martin Wood, Founder of Oxford Instruments.