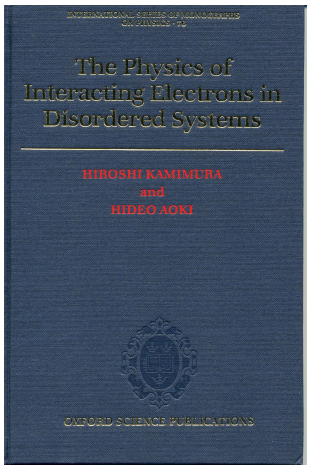
1 August 2005

# Research on "Theory of Impurity Bands in Doped Semiconductors"

## Abstract




In the period of June 23-29 Kamimura visited the Ioffe Institute as a guest researcher of Russian Academy of Sciences. During his stay in the Ioffe institute he gave a series of lectures on theory of impurity bands, theory of superionic conduction and theory of copper oxide high temperature superconductivity. In his lecture on the theory of impurity bands the concept of impurity bands and the phenomena of impurity conduction characteristic of the impurity band were first described following the idea of Sir Nevill Mott whose picture with Kamimura taken on March of 1994 is shown below. Then the overview of theoretical investigations for the interplay between disorder and electron-electron interaction in the impurity bands of doped semiconductors was given for the insulating regime of strongly Anderson-localized states in doped semiconductors, mainly based on the theories developed by Kamimura's group in 1980s described in the book by Kamimura and Aoki shown above. A theoretical formulation is developed starting from the intrastate interaction within each Anderson-localized state. Then the effects of the interstate interactions between neighboring Anderson-localized states are taken into account. In particular, the roles of electron-electron interactions in the specific heat and magnetic properties at low temperatures in the presence of magnetic fields were clarified, and theoretical results were compared with the experimental results on phosphorous-doped silicon (Si:P).In the second part of his lecture, the validity of the above-mentioned formulation was discussed through computer-simulation studies of interacting donor electrons in the intermediate concentration region of doped semiconductors. In this computer study an uncompensated system of doped semiconductors is simulated by a cluster model which consists of six donor impurities distributed randomly. It was shown that most of donor electrons below the metal-insulator transition form spin-singlet pairs and the remaining bonds are related to spin-triplet pairs due to Hund's coupling. In the final part of his lecture the effects of electron-electron interactions on transport properties in the presence of magnetic fields such as magnetoresistance were discussed, and theoretical results were compared with observed magnetoresistance in 1T-$TaS_2$ layer-type materials. For this talk recent experimental results on magneto-resistance and ESR-spin susceptibility were shown by experimental groups of the Ioffe Institute and useful discussions were made.

References:

H. Kamimura and H. Aoki, The Physics of Interacting Electrons in Disordered Systems (International Series of Monographs on Physics, Oxford University Press, 1989)

M. Eto and H. Kamimura, Phys. Rev. Lett. **61** (1988) 2790-2793

H. Kamimura, Impurity Bands, Chapter 8 in Crystalline Semiconducting Materials and Devices, eds. P.N. Butcher, N.H. March and M. Tosi (Plenum, 1986) P. 305-354