Physics of Crystal Defects — Prof. **Kazuo Nakajima** (Concurrently)

【Staff Members】

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【Research Activities】

In order to establish the knowledge of defects in semiconductors and also to apply them to new functions, the fundamental properties of various kinds of defects in various semiconductors, mainly in silicon and silicon-germanium, have been investigated for controlling their properties for applications.

The paper (**Ref.*1***) reports the Czochralski growth of bulk crystals of Si_xGe_{1-x} alloys in the whole composition range and their fundamental properties clarified as a distorted atomistic structure, electrical and thermal transportations, impurity lattice-site occupation, and thermo-mechanical strengths, originating from the alloying effects. In the paper (**Ref.*2***) the photoluminescence characteristics of fresh dislocations introduced by plastic deformation into GaN bulk single crystals are reported in a view point for developing the high efficiency blue light emitting. The paper (**Ref.*3***) summarizes the direct observation of atomistic structures of dislocations and defects in GaAs by high-resolution transmission electron microscopy. In the paper (**Ref.*4***) the diffusion of Au impurity in Si is reported under the effects of B impurity in high concentrations and dislocations and is discussed in a kick-out mechanism together with segregation at dislocations. This result addresses the recent trend of the applications of low resisitivity Si crystals for nano-aturized devices. The paper (**Ref.*5***) reports the dynamic interaction between dislocations and various impurities in Si in a viewpoint of out-looking the future trends, challenges and demands for strain control at the film/substrate interface.

1. I. Yonenaga
Growth and Fundamental Properties of SiGe Bulk Crystals
J. Cryst. Growth 275 (2005) 91-98.

2. I. Yonenaga, H. Makino, S. Itoh and T. Yao
Photoluminescence study of GaN with dislocations introduced by plastic deformation
Physica Status Solidi (c) 2 (2005) 1817-1821.

3. I. Yonenaga
Atomic structure of defects in semiconductors
"Encyclopedia of Nanoscience and Nanotechnology, Vol. 1", edited by H. S. Nalwa, American Scientific Publishers, 2004, p. 135-145.

4. A. Rodriguez and H. Bracht and I. Yonenaga
Impact of high B concentrations and high dislocation densities on Au diffusion in Si
J. Appl. Phys. 95 (2004) 7841-7849.

5. I. Yonenaga, T. Taishi, X. Huang and K. Hoshikawa
Dislocation-Impurity Interaction in Czochralski-Grown Si heavily doped with B and Ge
J. Cryst. Growth 275 (2005) e501 - e505.

【Plan】

The aim is to clarify the fundamentals on a variety of properties and elementary processes of defects and their mutual reactions in semiconductors in order to provide insights for developing the semiconductor technology with optimized control engineering of defects and to establish the science of imperfection in materials finally.

In the next 5 years, the current researches will continue, i.e., the electrical, optical and dynamic properties of various defects and their degradation modification under a variety of external conditions should be clarified physically in almost all kinds of available semiconductors and the applications of their nano/quantum features to create functional devices. In addition, the followings have been kicked off

(1) To investigate the mechanism of defect induction by strains at hetero-structural interface and to develop as stress/strain control engineering in the elemental semiconductors as Si, Ge, and so on, and then other kinds of semiconductors.

(2) To clarify the magnetic-field effects on defect properties.

(3) To create next-generation IV-IV compound semiconductors and to develop the new devices with their structural imperfections (perturbations and defects).

Many novel semiconductors have been proposed and are in research at present. The situation will continue in future. Thus, the survey of such materials on their status, trend, challenge and demands, should be inevitably important for outlook of the suitable direction in future.

In the long term, science of imperfections in a variety of materials, including semiconductors, metals, oxides, is aimed to be established, since material creation and functions can be performed by suitable utilization of such imperfections.