Development of High-temperature cBN Thin Film Devices for Severe Environments

Toyonobu Yoshida
(The University of Tokyo, School of Engineering, Department of Materials Engineering, Professor)

【 Outline of survey 】

Recent dramatic development in computers and cell phones are due with no doubt to a rapid advancement of the ULSI device technologies based in the single crystal silicon semiconductors. However, stop working and listen carefully, then you will notice a hissing sound coming from your PC - a noise from the fan inside to cool down the ULSI. The Si based device decreases its device performance with temperature and may drive uncontrolled once exceed 200 °C. This gives another indication that the operation of these devices is unwillingly limited by the temperature, not higher than 200 °C. Recent researches are therefore to aim the next generation high temperature electronic devices with SiC and diamond as " high temperature electronics " and indeed expanding as a part of the national projects.

In view of these trends of developments, our group will challenge the well-advanced third generation high temperature semiconductor devices with cubic boron nitride (cBN). This material is made up with the lightest weight elements in the III-V group semiconductors, and is blessed with both high mechanical strength and high chemical stability. We have worked on the synthesis of cBN thin films with high purity and high crystallinity through a development of our own unique plasma processing technologies, which may permit us to believe that we have been one of the top leading runner in this field. The aim of this project is, therefore, to establish the physical and analytical backbone of nano-structured thin films and to demonstrate the first operation of high temperature electronic devices at well higher than 500 °C, based firmly on our accumulated fundamental knowledge in cBN.

【 Expected results 】

Advancement in " high temperature electronics " will bring a radical progress in the system controls at high temperature environments, leading more safety, convenience and comfort to both our daily life and society. Examples would be, for aeroplanes and automobiles, a direct sensing at elevated temperatures and an integration of control units with sensing parts inside the control units, which both will result in an enhanced safety and efficiency on another high level. The similar outcomes will be equally expected in any area of industries and is a clear potential of being a fundamental and elemental technology in the industrial development. In addition, this material, cBN, is theoretically thought to be an ideal material to realize laser oscillation and UV light emission, and thus expected to contribute much to an establishment of high speed communication system in the future highly networked information society as symbolized by " Ubiquitous ".

" Ultimate " type of semiconductor operating at high temperatures through an integration at " nano " scale underlines clearly an importance of scientific aspects of this project not only in nano-science&technology but also in a broad range of scientific advancement.

【 References by the principal researcher 】

1) H. Yang, C. Iwamoto, and T. Yoshida, Interface engineering of cBN films deposited on silicon substrates, J. Appl. Phys., 94(2), 1248-1251(2003)
2) K.Nose, K.Tachibana, and T.Yoshida, Rectification properties of layered boron nitride films on silicon, Appl. Phys. Lett, 83(5), 943-945(2003)

【 Term of project 】 FY 2004 — 2009 | 【 Budget allocation 】 87,300,000 yen

【 Homepage address 】 http://www.plasma.t.u-tokyo.ac.jp/