【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering I)

Title of Project : Breakthrough in the ultra-precision polishing process of diamond substrates as an ultimate device

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Research Area : Ultra-precision processing technology
Keyword : Special processing, CMP, PCVM

【Purpose and Background of the Research】

While LED and power devices are drawing attentions, made from semiconductor materials such as SiC or GaN, there is another ultimate level of devices, which is made from semiconductor diamond. Compared with the former materials, diamond crystals are extremely stable mechanically and chemically, due to which, as one of the reasons, the study of the ultra-precision polishing of diamond crystals has remained almost untouched in the present research area.

For the semiconductor diamond substrates, including SiC and GaN, formation method of laser-induced surface radical site will be studied to develop an innovative, closed CMP/PCVM integrated system, integrating PCVM (Plasma Chemical Vaporization Machining) method into a sealed polishing/CMP (Chemical Mechanical Polishing). This system, assisted by the photocatalytic reaction and plasma under the high pressure oxygen atmosphere, will be designed such that excellent polishing efficiency of several ten times that of the conventional polishing will be achieved producing high quality surfaces. This research is also attempted to systematize ultra-precision processing of hard-to-process materials for the next generation green devices, and to accelerate realization of such devices, contributing to build low carbon society.

【Research Methods】

In the light of designing a precision polishing process of hard-to-process materials, both pre-process and finishing process have important roles.

In the pre-process: ultra-micro defects (laser-induced surface radical site) are formed on the surface layer of workpieces (limiting to ~several 100 atomic layer) by a femtosecond laser. Formation of such laser-induced surface radical site induces chemical reactions by the mechanical polishing or CMP accompanying frictional wear, and also strong mechano-chemical reactions on the radical site, which makes polishing/CMP easier under the atmospheric pressure.

The finishing process: a prototype of a closed, CMP/PCVM integrated system will be designed. Here, polishing pads and slurries have a key role, which induce strong mechano-chemical reactions on the laser-induced active surface radical layer and chemical reactions accompanied by the tribological frictional wear. In order to induce more effective etching actions, it is under consideration to keep inside the integrated system to high pressure oxygen atmosphere.

【Expected Research Achievements and Scientific Significance】

Fierce competitions are being driven for the development and applied studies of green devices as well as for the low cost production. Under this situation, introduction of innovatively integrated processing technology will become a breakthrough in achieving better productivity and low cost, offering a competitive edge in the industries.

The present research will contribute not only to the green device development but also to the leading edge manufacturing industries of Japan, bringing new energy to Japan. This research will make processing of hard-to-process materials possible such as diamond substrates including SiC and GaN. Particular aim has been placed to obtain high quality surface of diamond substrates with the reduced polishing time of less than one thousandth of conventional polishing.

【Publications Relevant to the Project】

[1]O. Ohnishi, T. Doi, S. Kurokawa et al.:Effect of Atmosphere and Ultaviolet Light Irradiation on Chemical Mechanical Polishing Characteristics of SiC Wafers, JJAP, 51(2012)05EF05-1

[2] Y. Sano, T. Kato, K. Aida et al.: Thinning of 2-inch SiC Wafer by Plasma Chemical Vaporization Machining Using Cylindrical Rotary Electrode, Materials Science Forum, 679-680 (2011) pp. 481-484

[3]T. Doi, I. Marinescu and S. Kurokawa:Advances in CMP/Polshing Technologies, Elsevier (2011)

【Term of Project】 FY2012-2015

【Budget Allocation】 165,600 Thousand Yen

【Homepage Address】

http://premach903.mech.kyushu-u.ac.jp/

(Tentative)