Sensors and Materials, Vol. 26, No. 6 (2014) 403–415
MYU Tokyo

S & M 1008

Novel Chemical Mechanical Polishing/Plasma-Chemical Vaporization Machining (CMP/P-CVM) Combined Processing of Hard-to-Process Crystals Based on Innovative Concepts

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(Received February 10, 2014; accepted March 10, 2014)

Key words: chemical mechanical polishing (CMP), plasma-chemical vaporization machining (P-CVM), combined processing, hard-to-process crystals, pseudoradical area, removal rate, surface roughness, ultraprecision processing

In this research, we aim to establish systematic knowledge of ultraprecision processing of hard-to-process crystal wafers for next-generation "green devices", and design and develop a high-efficiency, high-quality process to contribute to an early commercialization of SiC, GaN, and diamond-based devices demanded for a low-carbon society. Upon designing an ultrahigh-precision process for hard-to-process materials, we divided the process into two steps: a pretreatment step and a finishing step. In the pretreatment step, a pseudoradical area was formed by introducing ultrafine defects to control the surface condition suitable for finishing. In the finishing step, we attempted to combine the closed-chamber chemical mechanical polishing (CMP) and plasma-chemical vaporization machining (P-CVM) methods. To evaluate the concept of the second step, a fundamental study needed to design and prototype the machine was conducted. As a method of creating a pseudoradical area, femtosecond (fs) laser irradiation and coarse processing (grinding), which leaves a crystallographically disordered layer, were considered. Microindentation test, cross-sectional transmission electron microscopy (TEM) observation, Raman spectroscopy, X-ray photoelectron spectroscopy (XPS) and reflection high-energy electron diffraction (RHEED) were used to confirm the

pseudoradical area at the uppermost surface. Also, we studied the characteristics of the pseudoradical substrates subjected to CMP and P-CVM. P-CVM showed an increased processing rate for the pseudoradical substrates having microdefects. It will be necessary to optimize the degree and depth of crystallographic disorder in the pseudoradical area in the future. On the basis of the results presented here, we are starting to prototype the innovative CMP/P-CVM combined processing machine, which can selectively flatten the nanotopographies of hard-to-process materials by conducting CMP and P-CVM while continuously creating a pseudoradical area through an *in situ* physical effect such as polishing.

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