Unusual Elastic Behavior of Nanocrystalline Diamond Thin Films

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Nanocrystalline diamond (NCD) thin films (Fig. 1) are deposited by chemical vapor deposition method incorporating a few amount of N_2 gas to reduce the grain size. The incorporated N_2 gas generates sp^2 bonded regions in NCD films, which deteriorates the attractive properties of diamond thin films such as high hardness and stiffness. The anisotropic elastic constants of the NCD thin films are important for designing the electronic devices and evaluating the microstructure, because they are sensitive to defects, incohesive bonded regions, and impurities.

In this paper, the elastic constants of NCD thin films are measured by resonant ultrasound spectroscopy (RUS, Fig. 2) and Brillouin oscillation observed by femtosecond pump-probe method (Fig. 3). The increase of N_2 gas decreases the diagonal elastic constants, which is expected. The off-diagonal elastic constants, however, increase with the increase of N_2 gas, which is an unusual behavior (Fig. 4). The results can be consistently explained by the micromechanics calculation, and it predicts monocrystal graphitic phases formed along grain boundaries.

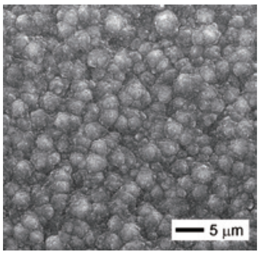

Fig. 1 Surface morphology of the NCD thin film deposited with 0.2 % N_2 gas.

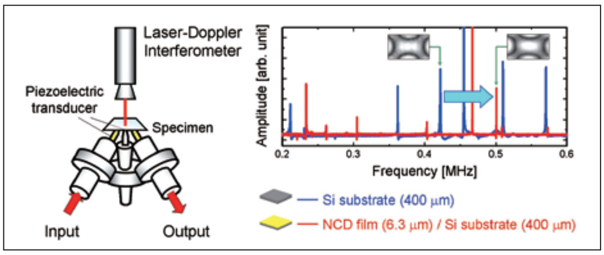

Fig. 2 Schematic of the RUS system, and the typical example of measured frequency spectra before and after the deposition. The two transducers generate and detect the ultrasound in the specimen, and the spectrum can be obtained by sweeping the input signal. The laser-Doppler interferometer can identify the vibration modes by scanning the film surface.

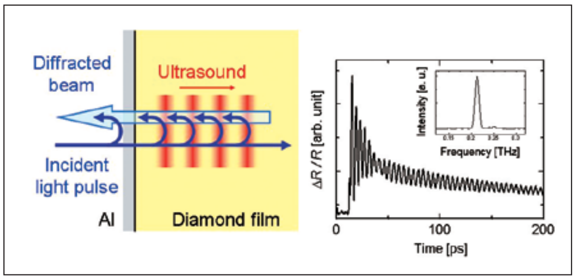

Fig. 3 Principle of the Brillouin oscillations, and the typical example of observed reflectivity changes. A light pulse irradiates the Al surface to generate the ultrasound, and time-delayed light pulse is diffracted by the ultrasound. The diffracted beam interferes with reflected pulse at Al surface, and the reflectivity changes are observed.

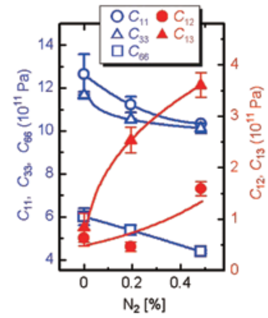

Fig. 4 N_2-amount dependence of diagonal (C_{11}, C_{33}, C_{66}) and off-diagonal (C_{13}, C_{12}) elastic constants.

KOMEKAMI Switch

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A KOMEKAMI switch is a wearable input device that uses the movement of the temples when a user clenches his or her back teeth. The device generates signals to control a machine by processing the values that the optical distance sensor captures, using a single-chip microcomputer, from the voluntary movements of the user's temples.

The user can use the machine for extended periods of time with no interference on their tasks, and the machine is hands free. It is compact and lightweight, allowing for ease of manufacturing at low cost. It does not react to daily actions, like conversation and food consumption; it only reacts to the movements intended to control the machine.

The KOMEKAMI switch is capable of operating music players, cellphones, television sets, air conditioners, room lighting, and other household electronics. Handicapped people would also be able to move wheelchairs using it.

Because a person does not have to move either hand, the system can serve as "a third hand" for caregivers, rock-climbers, motorbike drivers, and astronauts, as well as people with disabilities.