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# Precision machining of nano-polycrystalline diamond

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Neutron is a complementary probe to x-ray for material sciences at pressure, especially for hydrogen- bearing materials. A scientific proposal to build a dedicated high-pressure beamline at J-PARC had been accepted. Although funding for construction of this beamline is not yet established, a new scientific project aiming for neutron scattering at the highest pressure regime has started, which demonstrates the need of the beamline even clearer. Here we report our plan to go beyond the pressure limit of neutron scattering with an original high pressure cell.

Nano-polycrystalline diamond (NPD) is an alternative form of diamond material that is synthesized from graphite by direct conversion under excessively high pressure [1]. NPD consists of diamond grains with several tens of nanometers in size orienting in random directions. Therefore NPD has higher hardness than single-crystal diamond (SCD). In addition, it shows neither cleavage feature nor anisotropy of hardness those are weak points of SCD when it is used to generate excessively high pressure. One of the most important tasks to make further use of NPD in science and engineering applications is its precise machining into desired shapes. Polish-machining of NPD is much more difficult than that of SCD, although it is possible. The motivation of this study is thus to develop an alternative method for precise machining of NPD.

NPD samples were grooved or cut with several laser micro-processing system. The light source was diode-pumped solid state laser with frequency multiplier for THG (355 nm wavelength). We controlled important processing parameters to find suitable conditions for precise machining; those are (1) averaged laser power, (2) frequency of the Q-switch, and (3) work sending velocity against the beam.

The grooved and cut surfaces of NPD were observed by field-effect scanning electron microscope (FE-SEM) and by transmission electron microscope (TEM). FE-SEM is suitable to observe the shape and size of excavated debris from the grooves and cut surfaces, while TEM gave information about spatial distribution of various carbon phases under the cut surface those are transformed from diamond. From these observations we found that the machining involves several distinct process- es such as (1) absorption of light energy and its conversion to heat, (2) thermal cracking, (3) thermochemical reaction with air, (4) carbon evaporation and recondensation, and (5) solid-solid phase transformation. These processes changes their significance with the machining conditions described above. The problem here is how to reduce mechanical and thermal damages of the cut surface while keeping the processing fast enough, which will be discussed in the presentation.

[1] Irifune, T. et al. (2003) Nature, 421, 599-600