

# Synthesis, features, and applications of nano-polycrystalline diamond: Toward multi-Mbar pressures in multianvil apparatus

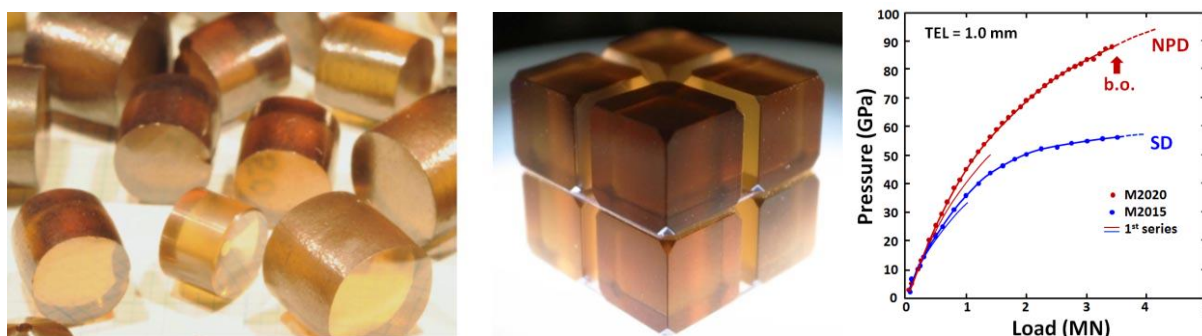
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Multi-anvil apparatus (MA) has advantages in synthesis of novel functional materials under ultrahigh-pressures (>10 GPa, by definition in materials science), because of its large sample volume, small thermal gradient, stable heating, etc., relative to those in competitive diamond anvil cell. We first succeeded in synthesis of pure nano-polycrystalline diamond (NPD) at pressures higher than ~15 GPa and temperatures above 2300K in MA [1], which was found to have peculiar nano-textures with ultrahard nature. By using a large-volume MA operated in a 6000-ton hydraulic ram at the GRC (BOTCHAN-6000), we are able to synthesize NPD rods with dimensions up to 1 cm, which have been used for various applications in high-pressure sciences, as well as for some other scientific and industrial applications.

One of such applications is to use NPD as anvils for higher pressure generation in MA. Pressures available in this apparatus using conventional tungsten carbide anvils have been limited to ~30 GPa except for those with very fine WC particles and less binders, where pressures to 50-60 GPa are reported [2,3]. Efforts have been made to expand the pressure limit by using harder sintered-polycrystalline diamond (SD) anvils, leading to the maximum pressure of ~120 GPa [4]. However, it seems quite difficult to reach pressures higher than this limit due to significant elastic deformation of the SD anvils. The anvil deformation also makes it difficult to perform in situ X-ray observations of the sample under pressure, as SD anvils contain metals such as Co as binders, which significantly absorb X-ray beams.

We have been trying to expand the pressure limit in MA using NPD anvils with two different approaches; one using a triple-stage (6-8-2) anvil configuration and the other with the conventional 6-8 system. The 6-8-2 MA with the third-stage NPD anvils led to pressures to 125 GPa at ~1000K [5]. For the latter 6-8 system with the second-stage NPD anvils, we confirmed pressures to ~90 GPa, which is about 1.5 times higher than the maximum pressure achieved using SD anvils with identical cell assembly (Fig.1). Attempts to further expand the pressure range are currently being pursued, which should lead to pressures of 150-200 GPa using MA with NPD anvils in the near future.



**Figure 1:** Raw NPD rods (left), NPD anvils for 6-8 MA (middle), and a comparison of pressure generation efficiencies in 6-8 MA with NPD and SD anvils (right, from [5])

## References

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