Superhard catalyst-free polycrystalline diamond developed

Hardness, thermal conductivity, impact resistance, and wear resistance are crucial in the development of new materials, including for the oil and gas industry. Currently, the most used material in nonferrous cutting materials, mining, and oil and gas drilling is the polycrystalline diamond compact (PDC). However, PDC does not provide sufficient impact or wear resistance and lacks adequate thermal stability. These

limitations derive from the use of a cobalt catalyst to bind the diamonds to form the PDC. When the catalyst interacts with the diamond grains, the diamond bonds weaken when the material is exposed to harsh cutting or drilling in high temperature and high stress environments.

In order to solve these limitations and improve the PDC cutter technology, Qiang Li and a group of researchers at Sichuan University, China; Drilling Technology Division, EXPEC ARC, Saudi Arabia; and Drilling Technical Department, Drilling and Workover, Saudi Arabia, have developed an ultrastrong catalyst-free polycrystalline diamond compact (CFPDC), as

reported in *Scientific Reports* (<https://doi.org/10.1038/s41598-020-79167-4>). This new material provides a much-needed technical solution by bringing a significant increase in performance, durability, and cost-effectiveness.

CFPDC is a superhard material created using ultrahigh pressure and ultrahigh temperature (UHPHT) technology. The material was evaluated to determine its properties such as wear resistance, hardness, and thermal stability that are critical features to consider in the oil and gas industry. CFPDC was synthesized under extreme high pressures of 16 GPa and an ultrahigh temperature of 2300°C. The new material showed a high wear resistance ~300% higher than the commercial PDC. The research team demonstrated that the CFPDC broke all single-crystal diamond indenters during hardness testing with a loading force larger than 9.8 N. Furthermore, CFPDC exhibited high thermal stability and oxidation resistance up to a temperature of 1200°C.

“The exceptional combination of the highest hardness, highest wear resistance, and highest thermal stability of the new CFPDC material is expected to play an important role in scientific research and in industries such as oil & gas exploration and drilling, tool cutting materials, semiconductor, [and] aerospace explorations,” the researchers wrote in their article.

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Optical images for the cutting edge of a catalyst-free polycrystalline diamond compact (CFPDC) sample (upper) with turning length of (a1) 420 m, (a2) 840 m, and (a3) 1260 m; and for the cutting edge of a commercial PDC sample (lower) with a cutting length of (b1) 420 m, (b2) 840 m, and (b3) 1260 m, respectively. Credit: *Scientific Reports*.

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