The Revolution of Diamond Synthesis Technology

James C. Sung *,1,2,3,a, Shao-Chung Hu[1,b], I-Chiao Lin[1,c], Chia-Cheng Tsai[1,d]

[1]KINIK Company, 64, Chung-San Rd., Ying-Kuo, Taipei Hsien 239, Taiwan, R.O.C.
[2]National Taiwan University, Taipei 106, Taiwan, R.O.C.
[3]National Taipei University of Technology, Taipei 106, Taiwan, R.O.C.
[a]sung@kinik.com.tw, [b]jameshu@kinik.com.tw,
[c]meetlin@kinik.com.tw, [d]babala@kinik.com.tw

Abstract

The ultrahigh pressure process for synthesizing diamond grits is due to make a quantum leap: the raw materials will incorporate diamond seeds with a predetermined pattern. The result is doubling the diamond yield with a narrower size distribution. Moreover, the shape of diamond crystals can be precisely tuned. For example, diamond octahedra or diamond cubes, that are not available today, can be mass-produced. The new technology is now being implemented worldwide so the future diamond grits will have improved quality at reduced prices.

Keywords : diamond synthesis, high pressure, diamond seed, diamond grit

Diamond Technology Revolutions

In 1954 GE of USA began to synthesize diamond grits under ultrahigh pressure (about 5.5 GPa) and at high temperature (about 1300℃). Subsequently, GE commercialized the process. The high-pressure reaction cell contained alternated layers of graphite and catalyst (Fe, Ni, Co or its alloy). When the catalyst melted in the diamond stability field, it would help graphite transform into diamond. The GE technology of using alternated layers had since become the industrial norm for diamond synthesis. All diamond makers worldwide used the same basic technology to make diamond grits.

In 1984 Winter of Germany developed an alternative process. Instead of using alternated layers of graphite and catalyst, the new process mixed powders of the two as well as microscopic diamond seeds as the precursor. This process could drastically improved the diamond distribution and hence the yield of commercial production. Winter process was introduced to GE, De Beers and Iljin Diamond in 1990s. This is the mainstream of commercial production of diamond grits.

In 2004, Dr. James Sung invented the ultimate process of synthesizing diamond under high pressure. The technology is based on positive planting of diamond seeds to form a predetermined pattern. As the result, each diamond has the optimal space to grow so every crystal has the potential to become perfect. Moreover, as there is no space unutilized so the diamond yield is the highest. Sung's process may be commercialized by major diamond makers in the world beginning in 2006. If so, the diamond industry will see a rapid declining of diamond grit prices that should benefit the ecomical development worldwide.

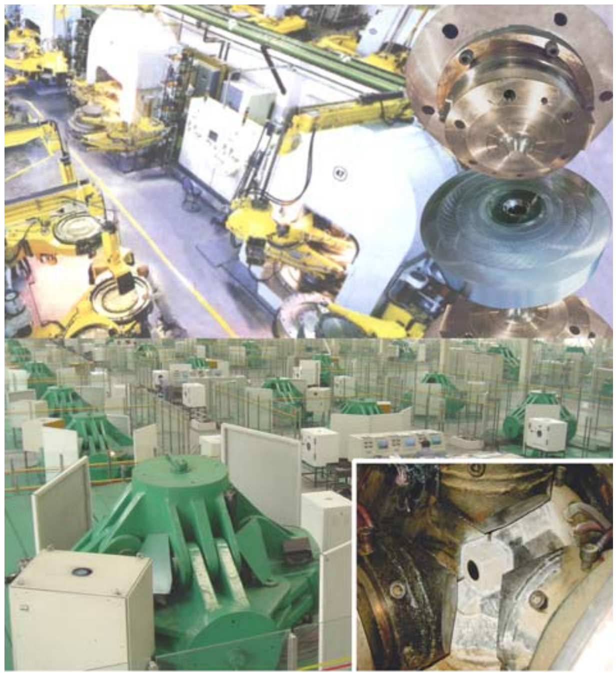

Fig. 1. The diamond manufacturing plant with belt apparatuses (top diagram) and cubic presses (bottom diagram).

Fig. 2. The three revolutions of diamond synthesis.

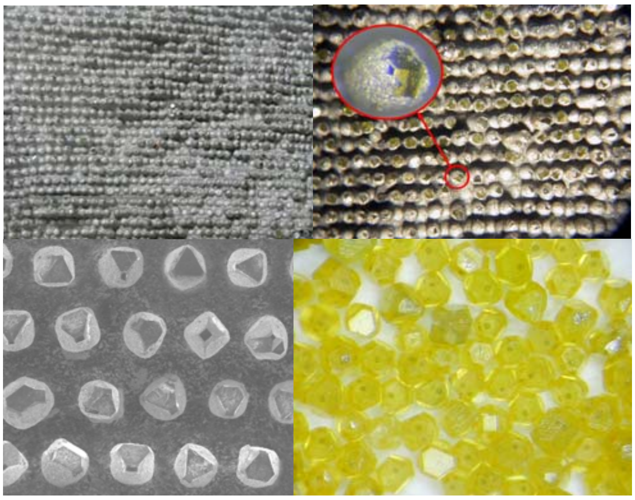

Fig. 3 . The cloning of diamond crystals in the closest packing with different magnifications, and the recovered diamond in its raw form without sieving and sorting. These diamonds were made in a 3000 ton cubic press that have not been able to produce the coarse mesh (30/40) size of diamond grits before as depicted in the pictures.

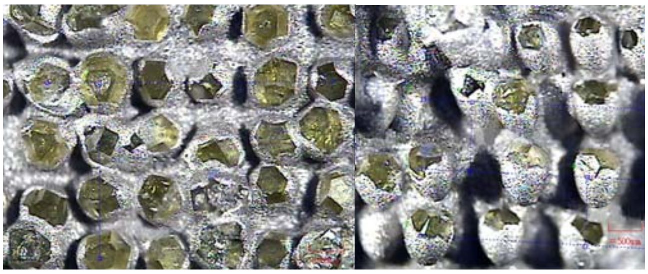

Fig. 4 . 30/40 mesh diamond grown on micron-sized seeds in an 800 ton belt apparatus. The Left figure shows the horizontal plane of the broken cell; and the right one, vertical plane. Note the floating of diamond above the molten iron-nickel alloy catalyst.

The patterned seeding technology can grow diamond in same size and shape. Furthermore, unique diamond shape that was not available before can now be mass-produced.

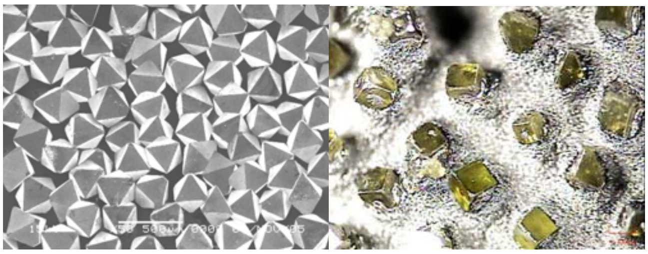

Fig. 5. The octahedral diamond (left diagram) recovered from the cell, and the cubic diamond (right diamond) formed in-situ by patterned seeding technology.

References

1. Chien-Min Sung, "A Century of Progress in the Development of Very High Pressure Apparatus for Scientific Research and Diamond Synthesis", High Temperatures-High Pressures, Vol. 29, p253-293. (1997)
2. Chien-Min Sung, "Optimized Cell Design for High-Pressure Synthesis of Diamond", High Temperatures-High Pressures, Vol. 33, p489-501. (2001)
3. Chien-Min Sung, U.S. Patent 6,286,498. (2001)
4. Chien-Min Sung, "Superabrasives and Diamond Synthesis", 600 pages book. (2003)
5. Chien-Min Sung, "Diamond Films and Diamond-Like Carbon", 600 pages book. (2003)
6. Chien-Min Sung, "Ultrahard Materials and Diamond Technology", 600 pages book. (2003)
7. Chien-Min Sung, U.S. Publication 20040194689. (2004)
8. Chien-Min Sung, U.S. Publication 20050136667. (2005)
9. Chien-Min Sung, U.S. Publication 20050153010. (2005)
10. Chien-Min Sung, U.S. Publication 20060016127. (2006)
11. Chien-Min Sung, U.S. Publication 20060032429. (2006)
12. Chien-Min Sung, U.S. Publication 20060032431. (2006)
13. Chien-Min Sung, Michael Sung, Emily Sung, "Diamond Growth on an Array of Seeds: The Revolution of Diamond Production", Thin Solid Films, Vol. 498, p212-219. (2006)