Modern Thermodynamics for Carat-size Synthetic Diamonds

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The carat-size single-crystal synthetic diamonds have been grown with very high growth rate by Yan et al. [1] in recent years of the 21st century. That is an important breakthrough of the activated low-pressure chemical vapor deposition (CVD) diamond technology since 1970s. However, the activated CVD diamond technology had puzzled classical thermodynamics for about 30 years. That is the reason, why the new diamond technology had been regarded as "thermodynamic paradox" maybe "violating the second law of thermodynamics" for a long time. Based on nonequilibrium nondissipative thermodynamics of modern thermodynamics [2], it is easy to be explained even quantitatively by nonequilibrium phase diagrams of carbon-hydrogen system in this paper.

The improved microwave CVD equipment provides a very stable and effective activation for the carat-size single crystalline synthetic diamond growth. The effective activation greatly extended the diamond growth phase region in the nonequilibrium phase diagram of carbon-hydrogen system. The supersaturated concentration of carbon at a little higher pressure (160 Torr) under very effective activation makes the diamonds growing with 2 orders of magnitude of rate faster than the traditional microwave CVD diamond technology (about 20 Torr) developed in 1980s and 1990s.

The carat-size single-crystal synthetic diamonds together with its thermodynamic theory are not only the symbol of wealth in economics but also in thermodynamics coming entirely from its classical stage to its modern stage.
Moreover, modern thermodynamics provides a new understanding on Belousov-Zhabotinsky reactions, which are usually called as "chemical oscillation". These reactions are really spiral reactions in nature.

[1] C.-S. Yan et al., PNAS **99**, 12523 (2002), and Phys. Stat. Sol. **201**, R25 (2004); R.J. Hemley, Y.-C. Chen, C.-S. Yan, Elements **105** (2005).
[2] J.-T. Wang, Nonequilibrium Nondissipative Thermodynamics, Springer, Heidelberg (2002); and Modern Thermodynamics, Fudan University Press, Shanghai (2005).