Extended Carnot Theorem

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Recently, a 10-carat beautiful diamond crystal has been obtained by the famous scientist Ho-Kwang Mao's group via an activated low-pressure chemical vapor deposition (CVD) process. The fundamental thermodynamic question of why a diamond can grow under low pressures arose after the achievement of an activated low-pressure CVD diamond in 1970's by Russian scientists. Y. Gogotsi *et al.* said that the thermodynamic coupling model that can be used to explain the formation of diamond in reactions (1) from graphite to diamond and (2) from super-equilibrium atomic hydrogen to molecular hydrogen have been well developed [1]. That is a comment on our thermodynamic model, which provides a unique quantitative explanation by nonequilibrium phase diagrams for activated low-pressure CVD diamond.

In classical thermodynamics, the equality of the second law was often regarded as equilibrium thermodynamics, but the Gibbs free energy minimization principle told us that the equality of the second law is not a sufficient condition for equilibrium. Now it has been confirmed that in modern thermodynamics the equality of the second law for multiprocess coupling systems, including simultaneous nonspontaneous reactions and spontaneous reactions, should be defined nonequilibrium nondissipative thermodynamics, or nondissipative thermodynamics for short [2]. It has also been found that the Carnot theorem should be extended into a generalized form. That is, nondissipative processes are of the highest efficiency for energy transformation, and reversible processes are a special cyclic case of nondissipative processes. The extended Carnot theorem is a new starting point for modern thermodynamics. The whole view of thermodynamics has been drastically changed. Modern thermodynamics can be used not only for low-pressure diamond and cubic boron nitride synthesis, but also for biological syntheses in life science.

[1] Y. Gogotsi *et al.*, *Nature* **411**, 283 (2001).
[2] J.T. Wang, *Nonequilibrium Nondissipative Thermodynamics*, Springer, Heidelberg, 2002.