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Thermodynamic theory of growth of nanostructures

X.L. Li [a,b], C.X. Wang [b], G.W. Yang [b,*]

[a] *MOE Key Laboratory of Laser Life Science & Institute of Laser Life Science, College of Biophotonics, South China Normal University, Guangzhou 510631, Guangdong, PR China*
[b] *State Key Laboratory of Optoelectronic Materials and Technologies, Institute of Optoelectronic and Functional Composite Materials, Nanotechnology Research Center, School of Physics & Engineering, Sun Yat-sen University, Guangzhou 510275, Guangdong, PR China*

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ABSTRACT

Self-assembled nanostructures, such as quantum dots (QDs), quantum rings (QRs) and nanowires (NWs), have been extensively studied because of their physical properties and promising device applications. To improve their physical properties and device applications, the fabrication of nanostructures with a uniform size, proper shape and regular position is desired in nanotechnology. Therefore, investigations of the growth process of nanostructures are highly important to control the self-assembly and synthesis processes of nanostructures flexibly. Thermodynamic theory as a universal approach to investigate material growth has been widely used to study the growth of nanostructures. This review covers the thermodynamic theoretical treatments of the growth of nanostructures, including QDs by epitaxy, QRs by droplet epitaxy, and NWs by the vapor–liquid–solid (VLS) mechanism. First, we introduce the thermodynamic models of the growth mechanisms of QDs by self-assembled epitaxy. The formation, stability, shape and position of QDs are discussed. Second, we introduce the nucleation thermodynamics and the growth kinetics of QRs by droplet epitaxy, and we present a simulation method employing the shape evolution of QRs based on a kinetic model. Third, several theoretical tools are introduced to address the nucleation and growth of NW by the VLS process. Finally, we introduce a thermodynamic treatment including the thermal fluctuations within the context of a statistical mechanical and

* Corresponding author.
E-mail address: stsygw@mail.sysu.edu.cn (G.W. Yang).

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quantum mechanical model for the temperature-dependent growth of nanostructures.

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