Temperature Dependence of Raman Scattering in 4H-SiC Films under Different Growth Conditions *

WANG Hong-Chao(王洪朝)[1], HE Yi-Ting(何依婷)[2], SUN Hua-Yang(孙华阳)[2], QIU Zhi-Ren(丘志仁)[2**], XIE Deng(谢灯)[1], MEI Ting(梅霆)[3**], Tin C. C.[4], FENG Zhe-Chuan(冯哲川)[5]

[1]*Institute of Optoelectronic Material and Technology, South China Normal University, Guangzhou 510631*
[2]*State Key Laboratory of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun YatSen University, Guangzhou 510275*
[3]*The Key Laboratory of Space Applied Physics and Chemistry, Ministry of Education and Shaanxi Key Laboratory of Optical Information Technology, School of Science, Northwestern Polytechnical University, Xi'an 710072*
[4]*Department of Mechanical Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia*
[5]*College of Physics Science and Technology, and GXU-NAOC Center for Astrophysics and Space Science, Guangxi University, Nanning 530004*

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The microRaman scattering of 4H-SiC films, fabricated by low pressure chemical vapor deposition under different growth conditions, is investigated at temperatures ranging from 80 K to 550 K. The effects of growth conditions on $E_2(TO)$, $E_1(TO)$ and $A_1(LO)$ phonon mode frequencies are negligible. The temperature dependences of phonon linewidth and lifetime of $E_2(TO)$ modes are analyzed in terms of an anharmonic damping effect induced by thermal and growth conditions. The results show that the lifetime of $E_2(TO)$ mode increases when the quality of the sample improves. Unlike other phone modes, Raman shift of A_1 (longitudinal optical plasma coupling (LOPC)) mode does not decrease monotonously when the temperature increases, but tends to blueshift at low temperatures and to redshift at relatively high temperatures. Theoretical analyses are given for the abnormal phenomena of $A_1(LOPC)$ mode in 4H-SiC.

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Silicon carbide (SiC), one of the most important semiconductor materials, has attracted increasing attention in terms of a material applied in high-temperature devices, high-power microwave devices, etc., due to its excellent physical and chemical properties such as high thermal conductivity, extremely high hardness, high saturated electron drift velocity, high break down electric threshold and low conductive constant.[1–6] Moreover, SiC can form a large number of polytypes, and the two most common polytypes, 4H- and 6H-SiC, have large crystal sizes. Compared with the latter, the larger band gap and higher electron mobility make the 4H-SiC a better material for high temperature, high power and high frequency applications.[7]

Raman spectroscopy, which has been widely used in studying materials including GaN,[8] SiC,[5] etc.,[9,10] has merits of non-destructiveness, fast analysis and requiring no special preparation for samples. The Raman parameters such as intensity, width, and peak frequency provide plenty of information on the crystal quality.[5] In terms of SiC, due to the strong covalence of the bonding, its Raman efficiency is high and the Raman signals can be easily detected.[5] Temperature is an important parameter that influences the performance of the optoelectronic device. Therefore, it is important to acquire details of the temperature dependence of the basic material properties, and better understanding of these properties can be helpful to improve the material and device quality. Han *et al.* studied the temperature dependence of Raman scattering in round pit of bulk 4H-SiC[11] and bulk 4H-SiC with hexagonal defects.[12] Sun *et al.* investigated temperature dependence of Raman scattering in bulk 4H-SiC with different carrier concentrations.[13] However, both of the reported studies are performed on the bulk 4H-SiC; the temperature dependence of Raman analysis of low pressure chemical vapor deposition (LPCVD)-grown 4H-SiC epilayers was rarely reported to the best of our knowledge.

In this Letter, we present Raman microprobe measurements from 80 K to 550 K on a series of 4H-SiC epilayers grown under different growth conditions (Si:C ratio and different reaction gas concentration), and report the temperature dependence of the optical modes in 4H-SiC. The anharmonic effect on phonon frequency, linewidth and lifetime are analyzed through a detailed theoretical model. The scattering model of the LOPC mode is employed to fit all measured Raman spectra and to analyze the temperature dependence of the LOPC mode.

The samples used in this study were 4H-SiC epi-