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Structural, optical and terahertz properties of Graphene-Mesoporous Silicon Nanocomposites

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Temperature dependent photoluminescence

Temperature varying PL spectra of the P_1 and P_2 bands are depicted in Fig. 1. Very little change in the emission energies and widths were observed within the 20 - 300 K range. The intensity of the bands slightly decreases with temperature. The extracted peak intensity changes from the inset in Fig. 1 (a) shows a ∼14% maximum drop for the P_1 and P_2 bands. Such a temperature-dependent behavior is often associated with a thermally-activated nonradiative recombination channel due to either carrier detrapping mechanism or ionization of excitons in this Si_xC_{1-x} thin layer. It is possible to extract the activation energy of such mechanism from the plot of the integrated PL band as a function of the temperature, using the proper Arrhenius model. These data curves are illustrated in Fig. 1 (b) for the P_1 and P_2 emission bands. These curves were fitted using the well known Arrhenius formula[1]

$$ln\left(\frac{I_0}{I(T)}-1\right) = ln(C) - \frac{E_a}{k_B T}, \tag{1}$$

where E_a is the activation energy, C is the ratio of the radiative lifetime to the non-radiative lifetime and I_0 is the integrated intensity at the lowest temperature.

Values of fitting parameters are $E_a = 19 \pm 2$ meV, $C = 0.31 \pm 0.07$ for the P_1 band and $E_a = 3.7 \pm 0.3$ meV, $C = 0.35 \pm 0.01$ for the P_2 band. The values of these fitting parameters indicate that carriers or excitons preferentially recombine radiatively at 300 K in this layer separating the Si nanocrystallites and the few-layer graphene coating. The energy position of the P_1 and P_2 emission bands are lower than that corresponding bandgap of the various SiC polytypes which varies from 2.3 eV for 3C-SiC to 3.2 eV for 6H-SiC. The activation energy of few tens of meV obtained for the P_1 band is consistent with the donor-bound exciton binding energy[2–4] found elsewhere for the various SiC polytypes. However, the temperature stability of both emission bands is also compatible with the radiative recombination of excitons strongly coupled to point defects in the SiC film[5]. For instance, Si vacancy related point defects, such as nitrogen-vacancy centres, were proven to be very stable in temperature. For the P_2 band, it may not be appropriate to use a thermal activation analysis for such a small variation of the PL signal between 20 K and 300K. Thus the low activation energy found could be simply associated with the fact that a small fraction of these defects are coupled to non-radiative traps.

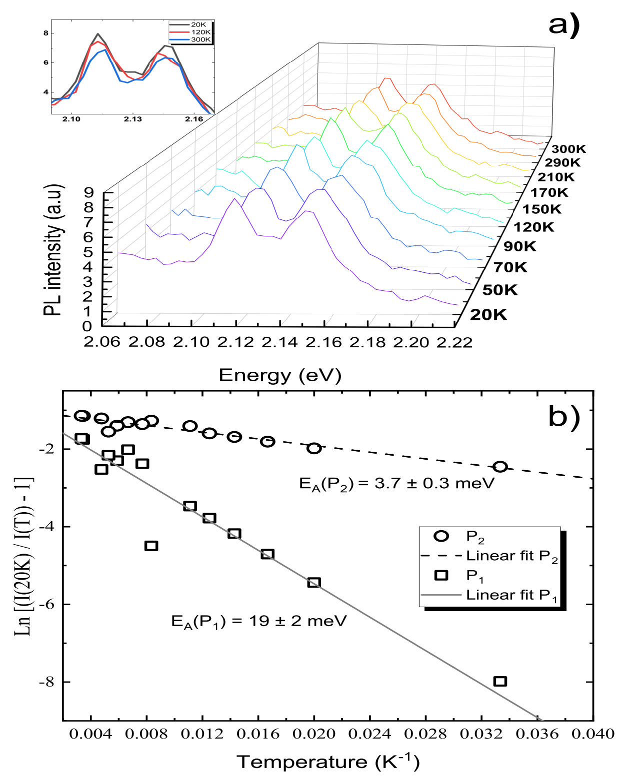

Fig. 1 (a) Temperature dependence of the photoluminescence signal from the P_1 and P_2 bands, observed at high energy in the spectra of the C750 sample. (b) Arrhenius plots of these two bands fitted using eq. 1.

Notes and references

1 A. W. Achtstein, A. Schliwa, A. Prudnikau, M. Hardzei, M. V. Artemyev, C. Thomsen and U. Woggon, *Nano Letters*, 2012, **12**, 3151–3157.

2 B. Segall, S. A. Alterovitz, E. J. Haugland and L. G. Matus, *Applied Physics Letters*, 1986, **49**, 584–586.

3 J. A. Freitas, S. G. Bishop, P. E. R. Nordquist and M. L. Gipe, *Applied Physics Letters*, 1988, **52**, 1695–1697.

4 J. Fan, X. Wu and P. K. Chu, *Progress in Materials Science*, 2006, **51**, 983 – 1031.

5 J. R. Weber, W. F. Koehl, J. B. Varley, A. Janotti, B. B. Buckley, C. G. Van de Walle and D. D. Awschalom, *Journal of Applied Physics*, 2011, **109**, 102417.