GEMAC Groupe d'Étude de la Matière Condensée

RADIATIVE LIFETIME OF BORON-BOUND EXCITONS IN DIAMOND STUDIED BY ULTRAVIOLET ABSORPTION

par Y. Kubo de l'Université de Tokyo

/**/<!-- /* Font Definitions */@font-face {font-family:Arial; panose-1:2 11 6 4 2 2 2 2 2 4; mso-font-charset:0; mso-generic-font-family:auto; mso-font-pitch:variable; mso-font-signature:-536859905 -1073711037 9 0 511 0;}@font-face {font-family:"Cambria Math"; panose-1:2 4 5 3 5 4 6 3 2 4; mso-font-charset:0; mso-generic-font-family:auto; mso-font-pitch:variable; mso-font-signature:-536870145 1107305727 0 0 415 0;}@font-face {font-family:Calibri; panose-1:2 15 5 2 2 2 4 3 2 4; mso-font-charset:0; mso-generic-font-family: auto; mso-font-pitch:variable; mso-font-signature:-520092929 1073786111 9 0 415 0;} /* Style Definitions */p.MsoNormal, li.MsoNormal, div.MsoNormal {mso-style-unhide:no; mso-style-qformat:yes; mso-style-parent:""; margin-top:0cm; margin-right:0cm; margin-bottom:10.0pt; margin-left:0cm; line-height:115%; mso-ascii-theme-font:minor-latin; mso-

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mso-fareast-language:JA;}@page WordSection1 {size:612.0pt 792.0pt; margin:70.85pt 70.85pt 70.85pt 70.85pt; mso-header-margin:36.0pt; mso-footer-margin:36.0pt; msopaper-source:0;}div.WordSection1 {page:WordSection1;}-->/**//**/<!-- /* Font Definitions * /@font-face {font-family:Arial; panose-1:2 11 6 4 2 2 2 2 2 4; mso-font-charset:0; msomso-font-pitch:variable; generic-font-family:auto; mso-font-signature:-536859905 -1073711037 9 0 511 0;}@font-face {font-family:"MS 明 朝"; mso-font-charset:78; mso-generic-font-family:auto; mso-font-pitch:variable; mso-font-signature:-536870145 1791491579 18 0 131231 0;}@font-face {font-family:" MS 明朝"; mso-font-charset:78; mso-generic-font-family: auto; mso-font-pitch:variable; mso-font-signature:-536870145 1791491579 18 0 131231 0;}@font-face {font-family:Cambria; panose-1:2 4 5 3 5 4 6 3 2 4; mso-font-charset:0; mso-generic-font-family:auto; mso-font-pitch:variable; mso-font-signature:-536870145 1073743103 0 0 415 0;} /* Style Definitions */p.MsoNormal, li.MsoNormal, div.MsoNormal {mso-style-unhide:no; mso-style-gformat:yes; mso-style-parent:""; margin:0cm; marginbottom:.0001pt; mso-pagination:widow-orphan; font-size:11.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-fareast-font-family: Cambria; mso-fareast-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansitheme-font:minor-latin; mso-bidi-font-family:"Times New Roman"; mso-bidi-theme-font: minor-bidi; mso-fareast-language:EN-US;}.MsoChpDefault {mso-style-type:export-only; mso-default-props:yes; font-size:11.0pt; mso-ansi-font-size:11.0pt; mso-bidi-font-size:11.0 pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-fareast-font-family:"MS 明朝"; mso-fareast-theme-font: minor-fareast; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; msobidi-font-family:"Times New Roman"; mso-bidi-theme-font:minor-bidi; mso-ansi-language: EN-GB; mso-fareast-language:JA;}@page WordSection1 {size:612.0pt 792.0pt; margin: 70.85pt 70.85pt 70.85pt 70.85pt; mso-header-margin:36.0pt; mso-footer-margin:36.0pt; mso-paper-source:0;}div.WordSection1 {page:WordSection1;}-->/**/

Recent progresses in doping control techniques for diamond accelerate the use of doped diamond in electronic applications. Because boron impurities play a unique and important role as acceptors providing p-type conductivity, boron-doped diamond has been intensely studied, e.g. by Hall effect measurements and infrared spectroscopy [1]. On the other hand, the boron-bound excitona complex formed due to capture of an exciton at a boron impurityhas so far been discussed only on the basis of cathodoluminescence (CL) [2, 3]. Although the bound excitons dominate the luminescence spectra, no absorption spectra had been measured so far. This situation impedes uncovering the bound-exciton recombination processes, which should be crucial for a deep understanding of its physical properties and optimization of diamond-based devices.

In this study, we measured the absorption spectrum due to boron-bound excitons in diamond near the absorption edge of the intrinsic diamond [Fig. 1(a)]. The investigated sample of 250 μ m thickness was synthesized by the plasma-assisted chemical vapor deposition (CVD) method with the boron concentration of 1.8×1018 cm-3 [4]. Based on the absorption cross section as shown in Fig. 1(b), the oscillator strength of the no-phonon (NP) lines was determined to be 3.0×10-5. This value satisfies the scaling law established for silicon between the oscillator strength and the localization energy. More importantly, we also assessed the oscillator strength of 1.2×10-3 for the transverse optical (TO) phononassisted transition, which dominates the spectra and provides an associated radiative lifetime of 1.8 μ s. The obtained radiative lifetime is two orders of magnitude shorter than that in silicon.

Our first successful measurements of ultraviolet absorption facilitate the prediction of radiative and non-radiative lifetimes of bound excitons in variously doped diamond by using scaling laws [5].

Figure 1 – (a) Absorption spectra of boron-doped (solid line) and intrinsic (dotted line) diamond near the band edge. (b) Enlarged NP lines showing the absorption cross section by the shaded area.

References

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