Ultraviolet light emission from diamond !

Purpose

We promote basic studies on ultraviolet (UV) light emitting diodes (LED) with wavelength shorter than 350 nm at Nanotechnology Research Institute in National Institute of Advanced Industrial Science and Technology. Compact and high-efficiency diamond UV light emitting sources have attracted much research interest because of their potential applications in biochemical detection, data storage, air-water purification, and phosphor excitation.

Result

Diamond has a potential to attain stable excitons in a very dense state compared to other semiconductor materials even at room temperature. This indicates that diamond can realize the quantum conditions even at room temperature, which is observed for Si at very low temperature. By using this superior nature of excitons in diamond, we have realized high-efficiency UV light emission, although diamond is indirect-transition semiconductor.

In this achievement, we fabricated diamond p-i-n junction diodes by sandwiching the intrinsic layer, which has low impurity concentration and low density of deep levels, between p- and n-type layers. The p-, i-, and n- layers were grown by microwave plasma-enhanced chemical vapor deposition (CVD). Our diamond UV-LED has significant characteristics as follows, 1) we have realized high-efficiency excitonic emission with the wavelength of around 240 nm at room temperature by current injection, 2) the internal quantum efficiency increased over one order compared to the conventional diamond p-n junction diode fabricated in our previous work , 3) the diamond UV-LED can operate even at temperature above 200℃, etc.

Outlook

It has been found that, using the excitonic emission, diamond can have an internal quantum efficiency close to the value of direct-transition semiconductors. This would be due to the excellent material properties of diamond. To practically use the diode fabricated in this study as an UV-LED, external quantum efficiency and voltage loss must be improved. Hereafter, we investigate the mechanism of excitonic emission for diamond in more detail, and explore fabrication processes and structures of high-performance devices for practical use.

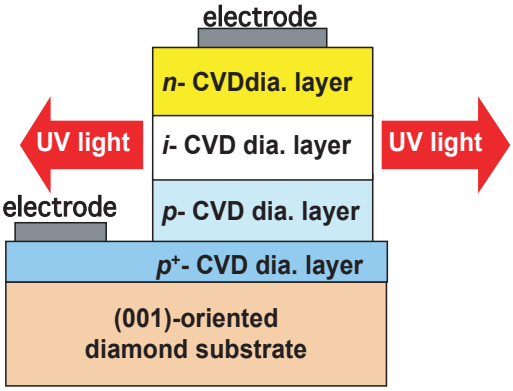

Fig.1 Structure of diamond UV-LED.

Fig.2 Diamond UV-LED (left) and UV light emission by current injection (right). Blue light can be seen at the same time as UV light emission.

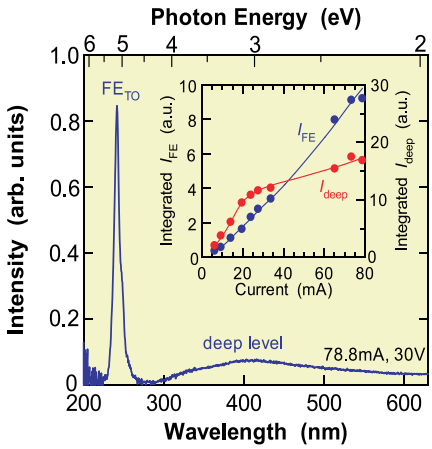

Fig.3 Current injected light emission properties for diamond UV-LED.

References

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- Patent Application No. JP 2006-228583