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Investigation of the absorption mechanisms of SiC for lighting applications

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Silicon carbide (SiC) was a pioneer optoelectronic material from which the first luminescence was observed [1]. Yet, its optoelectronic properties remain to get little attention. It is a wide bandgap material where its bandgap depends on the specific stacking arrangement of carbon and silicon bilayers. As a wide gap semiconductor material, its bandgap is suitable for white light generation by introducing artificial energy states within the bandgap. Its exceptional material properties, such as excellent thermal conductivity, high radiation resistance, high breakdown voltage, are suitable for high power white light generation [2]. Fluorescent silicon carbide (f-SiC) has proven to be a promising candidate with demonstrated capability to produce excellent color quality [3-5]. Donor-acceptor pair (DAP) recombination of N and B co-doped silicon carbide emits a broadband yellow light. Blue light emission can be achieved from either porous structures or from DAP recombination involving N donor and Al acceptor.

In the development of white light devices from SiC by conversion of NUV excitation, full understanding of the absorption parameters are crucial to engineer white light devices. Here we measured the absorption coefficients of 4H and 6H SiC polytypes over broad spectral ranges (see Fig. 1 a, b). The measurements show strong sub-band absorption in n-doped SiC samples, including near the band edge. These are caused by light absorption by the free electrons in the conduction band and the bound electrons at donor states [6]. While the sub-bandgap absorption with peak near 626 nm (for 6H SiC) affects the out coupling of the generated light, the near band edge absorption implies possible absorption of the excitation source by free carriers, consequently dissipating the excitation power. In a highly doped 6H SiC sample, excitation by 405 nm laser results in the dissipation of more than half of the excitation power. Similarly excitation of the highly doped 4H SiC by 375 nm causes more than half of the excitation power to be absorbed by free carriers. These experiments predict significant dissipation of excitation power in high injection conditions where high densities of free electrons are generated.

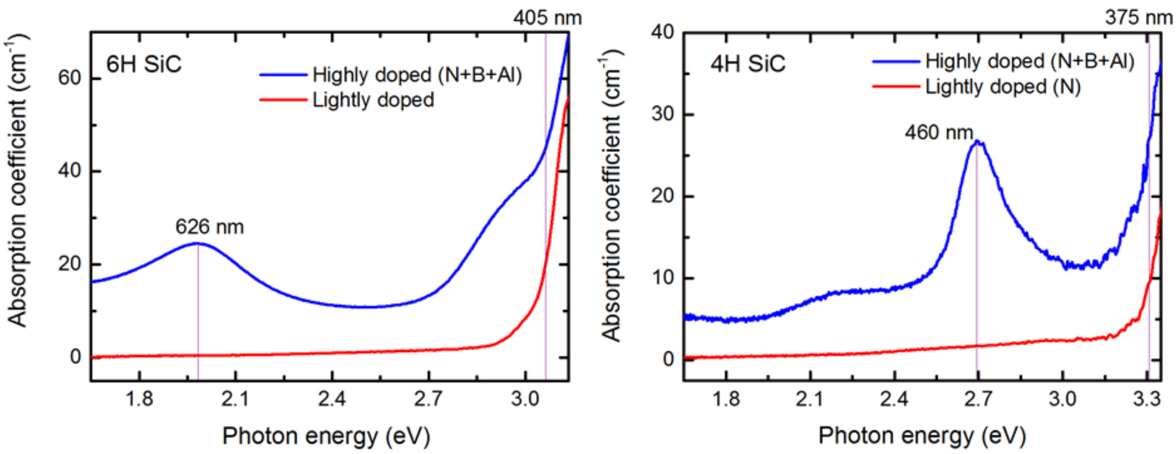

Fig. 1. Measured absorption coefficients of highly doped and lightly doped silicon carbide samples over broad spectral range: (a) 6H and (b) 4H SiC. The heavily doped samples are doped with nitrogen, boron and aluminium.

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