American Mineralogist, Volume 90, pages 428–440, 2005

Luminescence study of defects in synthetic as-grown and HPHT diamonds compared to natural diamonds

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ABSTRACT

The optically active defects in as-grown, high-pressure high-temperature-treated (HPHT), boron-doped, and synthetic diamonds (SD) grown with a nitrogen-getter, as well as of natural diamonds (ND), were characterized by absorption and luminescence spectroscopies using different excitation sources. The laser-excited photoluminescence (PL) spectra of SDs show numerous sharp lines characteristic for nickel-related centers, whereas NDs yield mainly broad PL bands. The emission from the nickel-related defects in NIR range increases and the maxima of the bands shift to lower energies with increasing temperature. Under UV and electron beam excitation, the yellow synthetic diamonds display green luminescence patterns along octahedral directions. The UV-excited PL spectra of the yellow SDs show a green band associated with nickel-related optical species. NDs display broad bands centered at ca. 450 nm that are related to complex nitrogen-related aggregates formed in the mantle in a long period of geological time. The cathodoluminescence (CL) spectra of SDs reveal many nickel-related and simple nitrogen-vacancy defects. Differences among as-grown, HPHT, and boron-doped diamonds can be observed. The CL bands of NDs are partly formed or caused by complicated nitrogen aggregates, like N3 and N4 centers. The CL band of NDs shifted from blue to green with increasing irradiation time. The deep-UV (DUV) excited time resolved PL spectra of NDs showed fast-decaying donor-acceptor pair recombination (DAPR) bands at around 410 nm. With longer delay and gate times, the broad band shifted to ca. 435 nm. All synthetic diamonds display luminescence from nickel-related defects centered at ca. 480 and 530 nm at room temperature (RT) and 77 K, respectively, and all SDs had a sharp luminescence band at 694 nm due to a Cr^{3+} impurity in corundum inclusions.