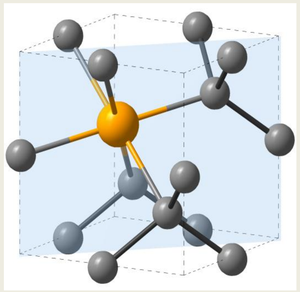
Discovery and Distribution of the [Si-V]$^-$ Defect in HPHT-Grown Gem-Quality Diamonds

Paul Johnson[1], Kyaw Soe Moe[1], U.F.S.D'Haenens-Johansson[1], Lorne Loudin[1] and Alexander Rzhevskii[2]

[1] Gemological Institute of America (GIA), New York, NY, USA. [2] Thermo Fisher Scientific, USA.

[Si-V]$^-$ Defect in Diamond



Silicon split-vacancy defect in diamond.

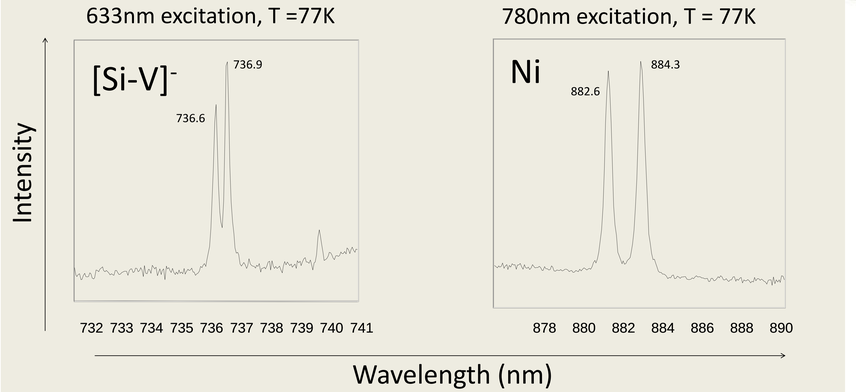
- Discovered and confirmed by ion-implantation, irradiation and annealing.
- Optically active to absorption and luminescence.
- Common defect in CVD synthetic diamond, and may be introduced unintentionally or by doping.
- The most important feature for CVD identification
- Occasionally observed in natural diamonds.
- Great interest as a potential system for quantum information technologies.

However, little is known about how Si is incorporated into the diamond lattice, which is the basis for using this feature in diamond identification and for any industrial development

Purpose of this study

- To determine [Si-V]$^-$ distribution in HPHT synthetic diamonds
- To understand its preferential incorporation in the lattice
- To discuss the implication of [Si-V]$^-$ in natural diamonds

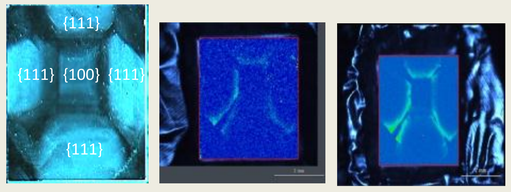
Single crystal HPHT grown diamonds can now exceed 30ct. The [Si-V]$^-$ defect common in CVD synthetic diamonds can also be detected in HPHT synthetic diamonds.



Low temperature (77K) photoluminescence spectroscopy revealed emission doublets at 736.6/736.9 nm and 882.6/884.3 nm. These peaks are attributed to the [SiV]$^-$ center and an interstitial Ni$^+$ atom distorted along a {111} direction, respectively. Studies have shown that the Ni-related center is exclusively found in the {111} growth sectors of HPHT grown diamonds.

New Diamond Technology (NDT) HPHT Synthetic Plates

20 HPHT synthetic diamond plates from NDT, approximately 5x5mm square were studied and mapped. The [Si-V]$^-$ defect was detected in 3 of the samples.

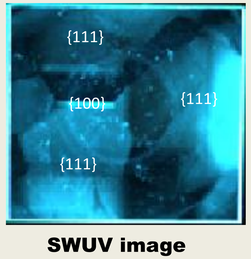


SWUV image

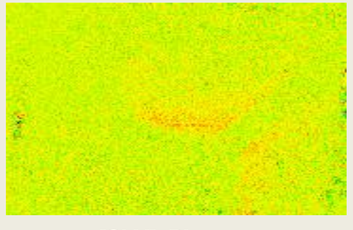
[Si-V]$^-$ PL map

Ni$^+$ PL map

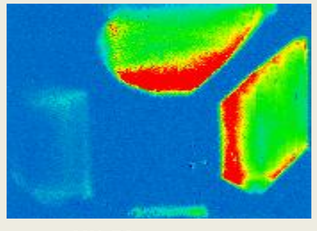
Diamondview^{tm} fluorescence imaging reveals the cuboctahedral growth sectors of the sample. PL mapping of the [SiV]$^-$ and Ni$^+$ interstitial defects reveal that they are both only detected in the {111} growth sectors, with higher emission intensities along the sector edges.



SWUV image



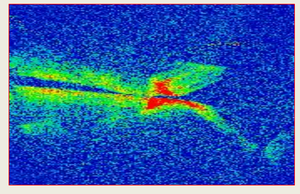
[Si-V]$^-$ PL map



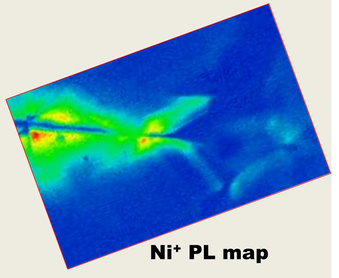
Ni$^+$ PL map

Client Submitted HPHT Synthetic Dimonds

E color, 1.04ct.

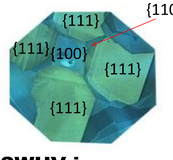


[Si-V]$^-$ PL map

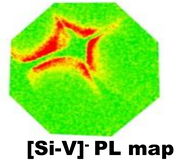


Ni$^+$ PL map

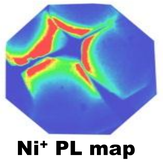
Vivid Blue, R 0.49ct.



SWUV image



[Si-V]$^-$ PL map



Ni$^+$ PL map

References:

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3. Tom Feng., Bradley D. Schwartz. Characteristics and origin of the 1.618 eV luminescence center in chemical-vapor-deposited diamond films. J. Appl. Phys., Vol. 73, No 3, 1 February 1993
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Summary

- [Si-V]$^-$ defect has been detected and mapped in HPHT synthetic diamonds, using low temperature PL.
- Like the Ni$^+$ interstitial defect, [SiV]$^-$ defect was only detected in the {111} growth sectors, with higher concentrations observed along the sector boundaries.
- Natural diamonds rarely have detectable [Si-V]$^-$, strongly indicated that crystallization might have happened in a Si-deficient environment.
- Further experiments are needed to better understand the incorporation of [SiV]$^-$ defects in synthetic and natural diamond by considering defect distributions. PL mapping may be used to understand the formation of defects in natural, synthetic and treated diamonds, potentially refining identification criteria.