Study of Diamond Growth Based on Nickel Distribution

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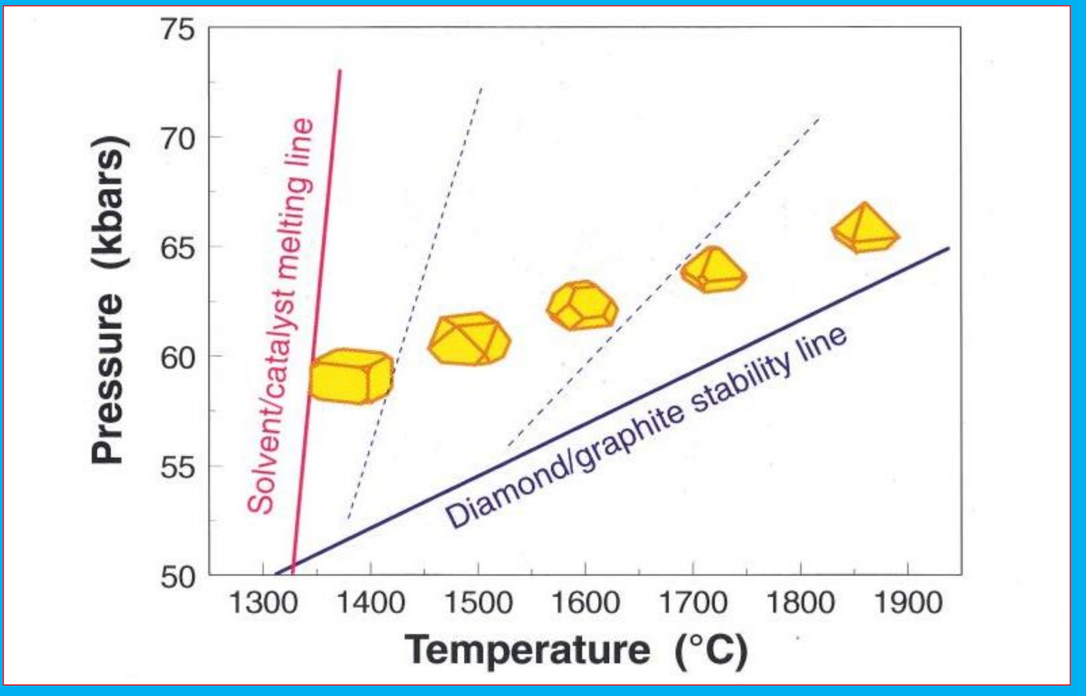
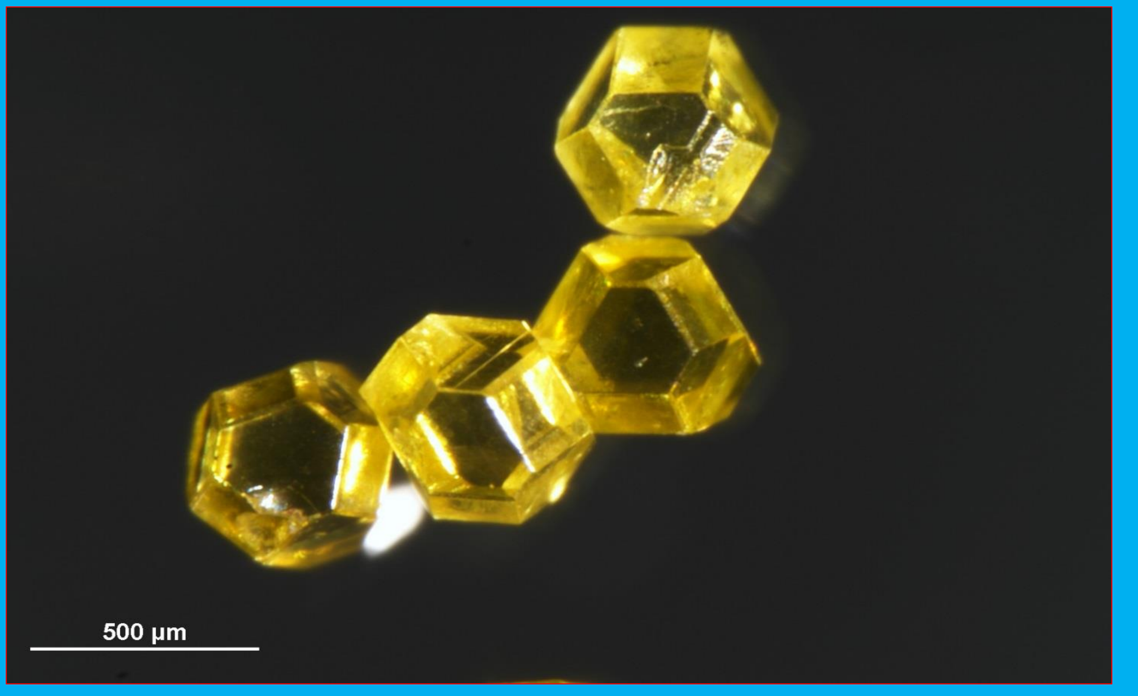
Synthetic melee produced in China at low cost and with high quality.

Many HPHT presses that can produce 180-300 carats per hour.



After Sunagwa 1984 Diamond growth morphology.



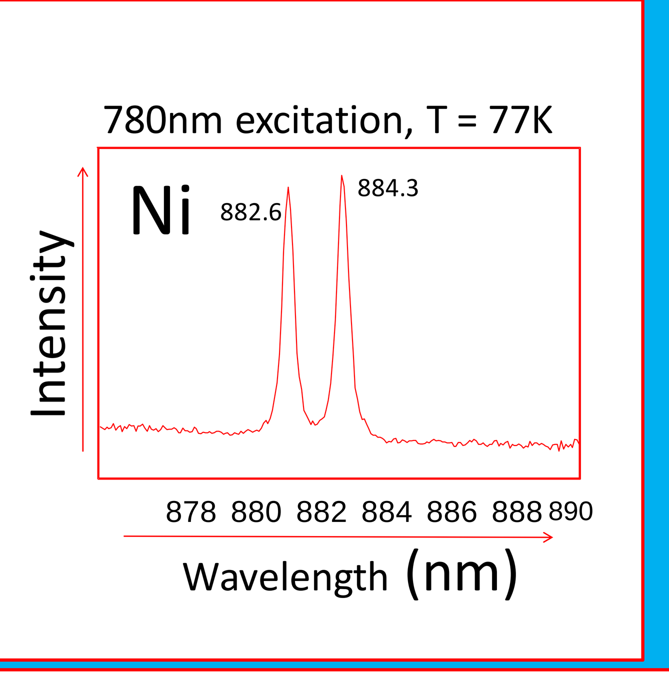
Yellow cubo-octahedral crystals. Temperature & pressure conditions promote different crystal habits. HPHT synthesis promotes cubo-octahedral growth.

Large amounts of gem-quality colorless diamonds have been produced using High Pressure High Temperature (HPHT) synthetic growth technology. The large crystals grown usually show typical cubo-octahedron morphology with well-developed {111}, {110} and {100} sectors. In contrast, the small melee crystals produced (~2 mm in size) usually show elongated shapes with many sharp growth lines at crystal surfaces. The growth habit of these small crystals is little understood. Very strong blue phosphorescence of these crystals prohibits observation of growth habits from fluorescence patterns. Nickel (Ni) is a common impurity in the diamond crystal lattice for both natural and HPHT grown synthetic diamonds. In this study, we analyzed the distribution of trace Ni impurity in HPHT grown synthetic and natural diamonds using laser Raman mapping technology (Johnson et al., 2015). Trace amounts of Ni can be easily excited using 830 nm laser excitation (photoluminescence) at liquid nitrogen temperature with a high sensitivity.

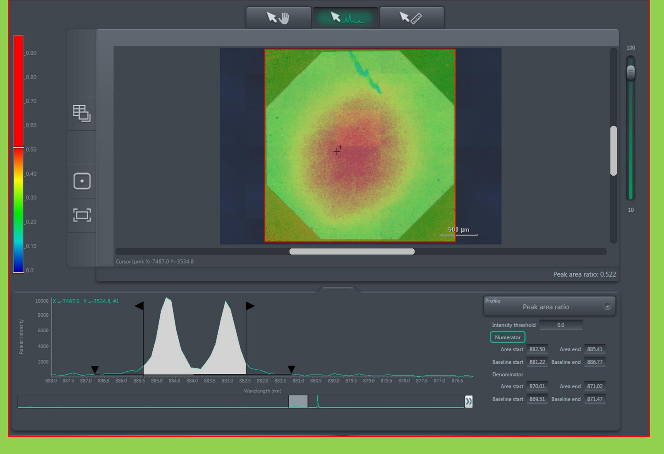
For the large cubo-octahedron synthetic diamond crystals it was found that Ni concentration is highly concentrated in {111} growth sectors separated by {110} and {100} sectors in which the Ni is below detection limit. This type of Ni distribution forms a characteristic "cross" pattern observed in these large crystals. For natural diamonds dominated by {111} growth only we found that Ni can be detected in only some specific types of diamond. Distribution of Ni varied from stone to stone with a relatively even distribution following growth zonation and within a localized area only. Mapping of Ni distribution in these melee synthetic crystals revealed multiple stages of growth which explained the elongated crystal morphology.

Nitrogen and nitrogen nickel complexes are preferential to the {111} growth sectors. This is observed in HPHT synthesized diamond crystals.

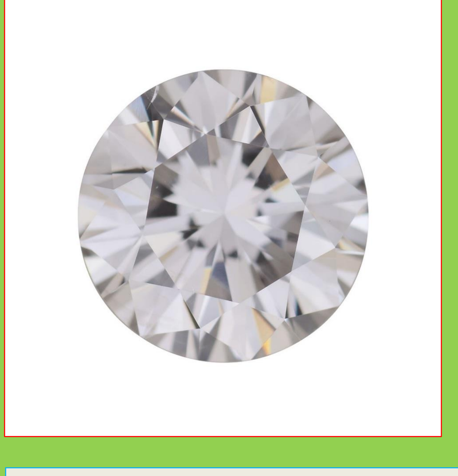
The interstitial nickel (Ni^+) can be excited by photoluminescence spectroscopy and a doublet peak detected at ~ 884nm this feature can be mapped.

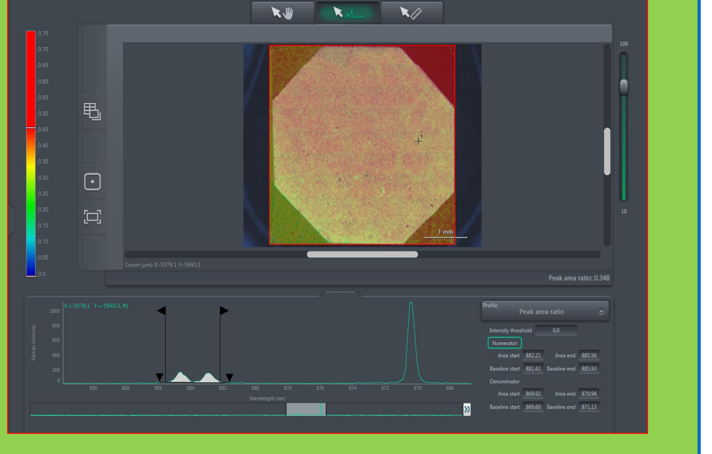


Natural Diamonds PL maps showing a random distribution of the nickel defect.



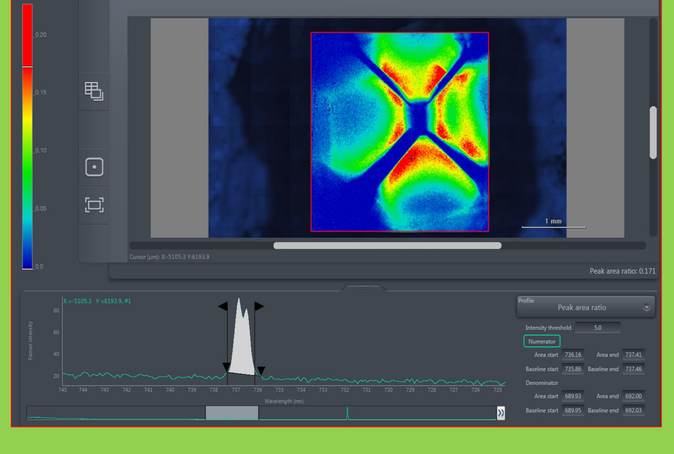
0.5ct near colorless natural diamond.



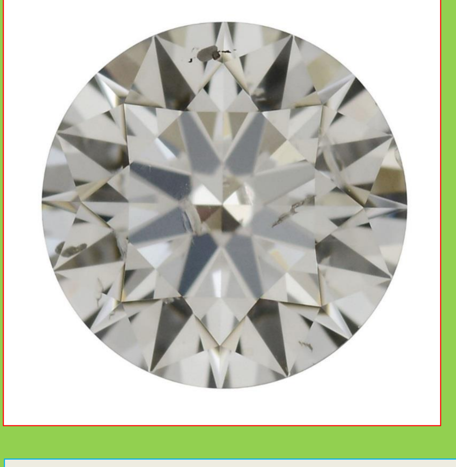


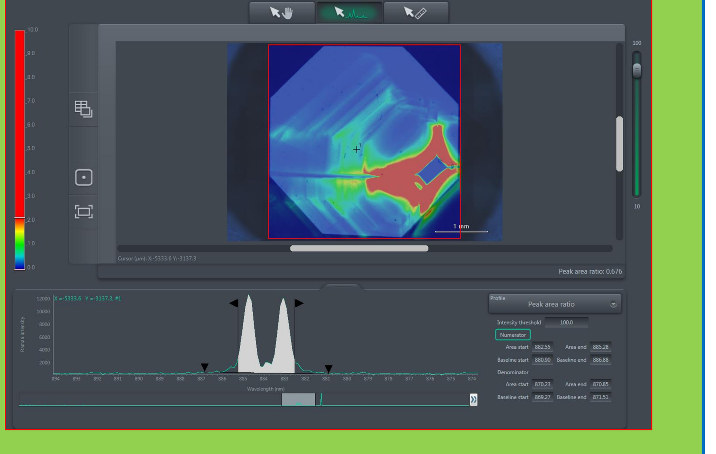
2.23ct near colorless natural diamond.

Lab-Grown HPHT synthetic Diamonds PL maps showing nickel confined to the {111} growth sectors.

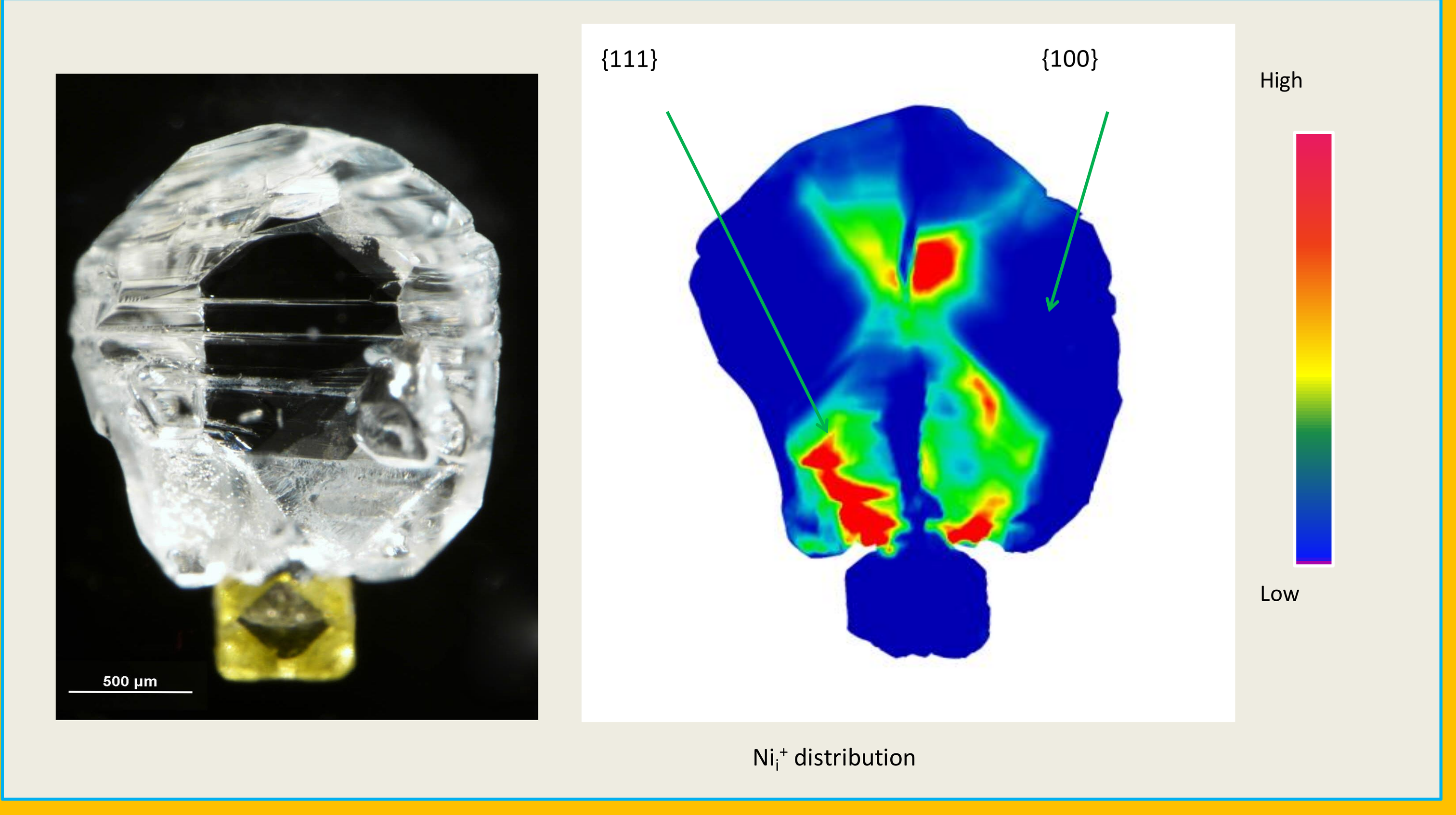


0.42ct Green HPHT lab grown diamond.





1.01ct near colorless HPHT lab grown diamond.



Random distribution observed in natural diamonds compared to the synthetic diamonds with nickel confined to the {111} growth sectors. As nitrogen incorporation into the crystal lattice is preferential to the {111} sectors nickel nitrogen complexes are also dominant in these sectors.

References:

S.C. Lawson, H. Kanda, Nickel in diamond: an annealing study, Diamond and Related Materials, 2 (1993) 130-135. 1993

P. Johnson, K. S. Moe, U. F.S. D'Haenens-Johansson, A. Rzhevskii, Discovery and Distribution of the [Si-V]-Defect in HPHT-Grown Gem-Quality Diamonds, 2015 GSA Annual Meeting, Paper No. 300-12

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Elongated crystals are grown usually oriented in the {100} direction with the nickel impurity confined to the {111} sectors. Rapid growth and fluctuating temperatures may contribute to the elongated crystals see the striations in the above crystal.

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