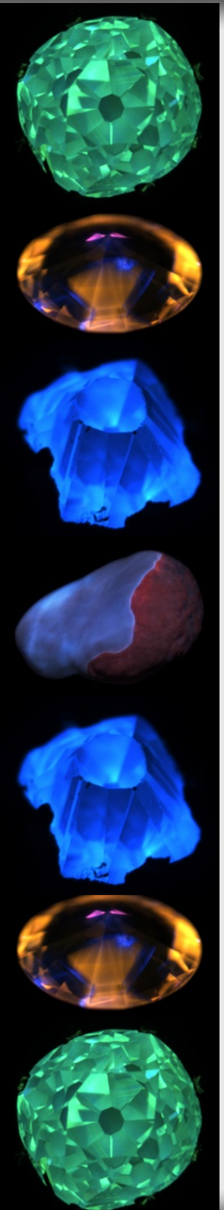

When gemstones glow: emission phenomena of diamond, ruby, sapphire & Co.

Thomas Hainschwang

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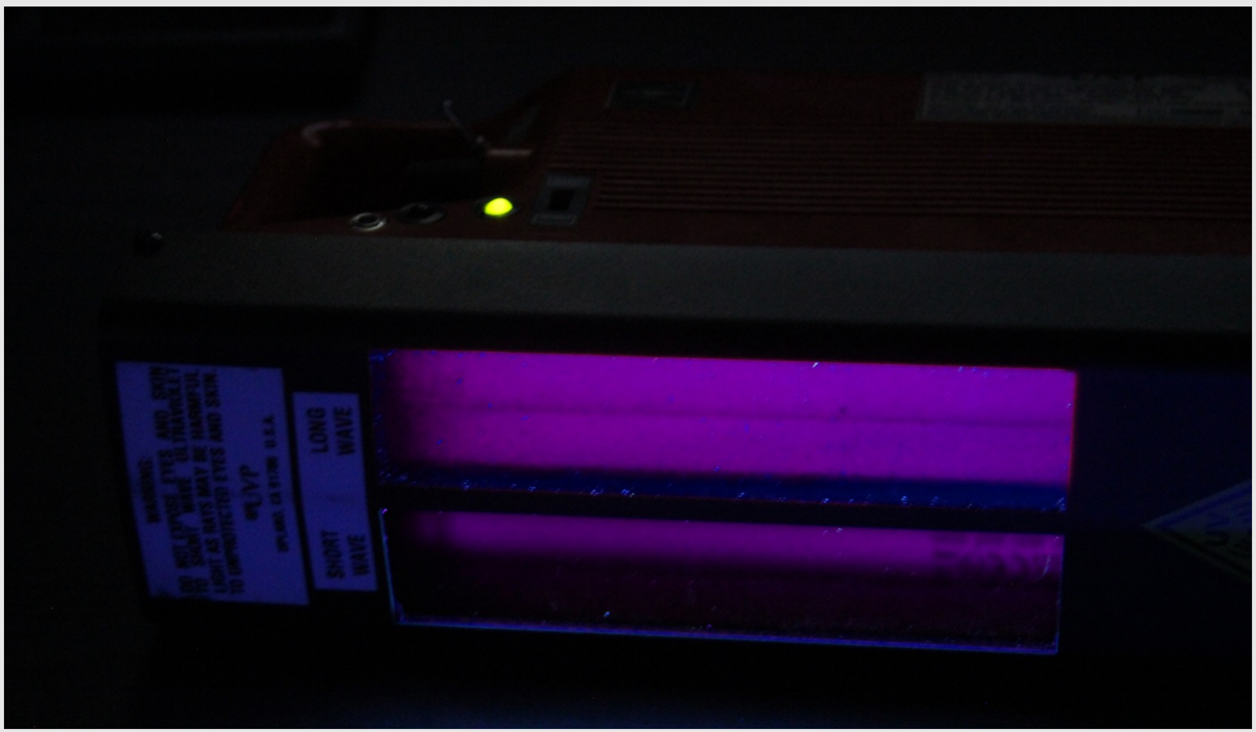
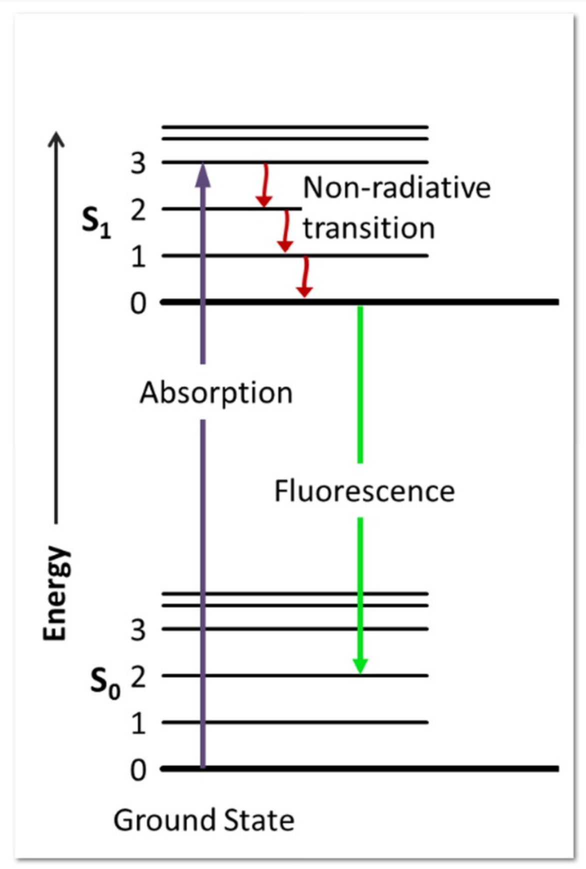
GGTL Laboratories, Balzers (Liechtenstein) and Geneva (Switzerland)

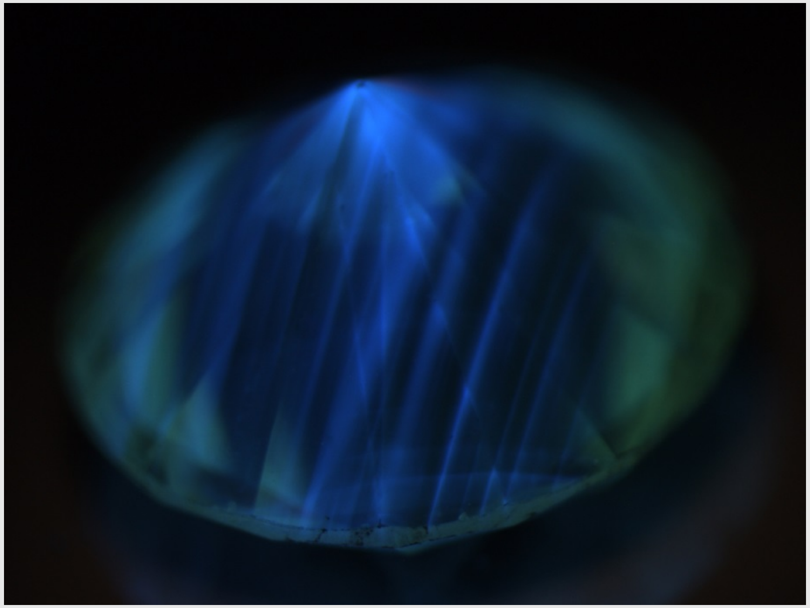
Gemology Workshop, University of Geneva, 2014

A simple tool to make gemstones "glow" – the UV lamp: longwave (365 nm) and shortwave (254 nm) UV



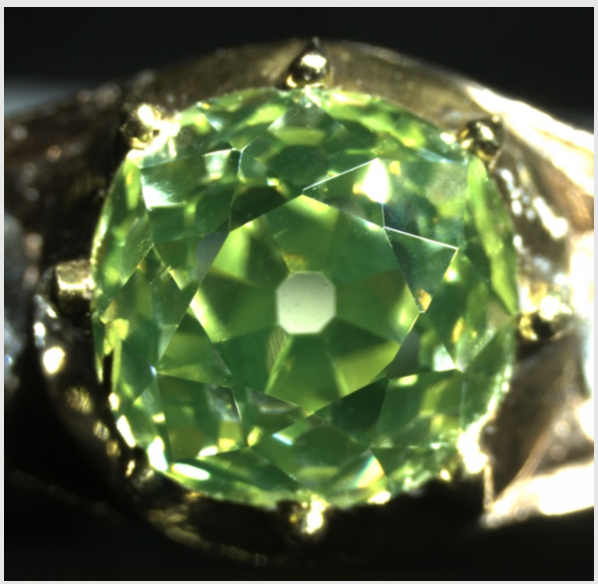
What is fluorescence?

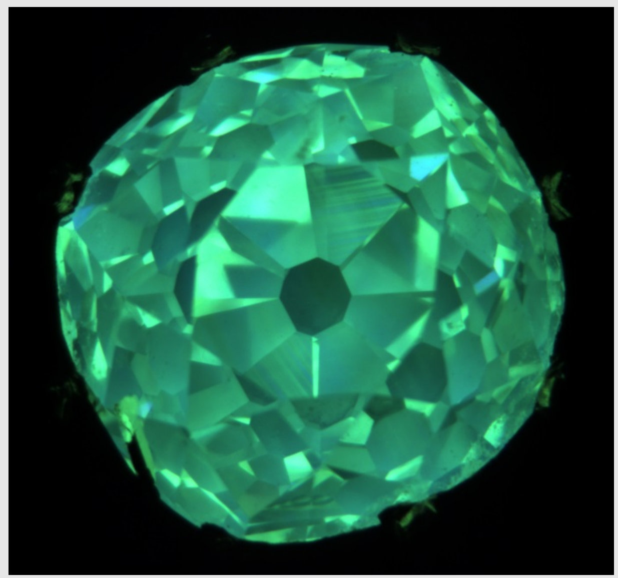


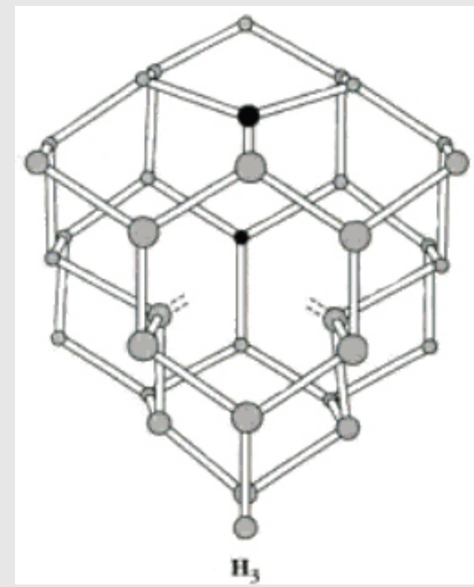


Example H3 defect in diamond:

Apparent color by absorption + luminescence

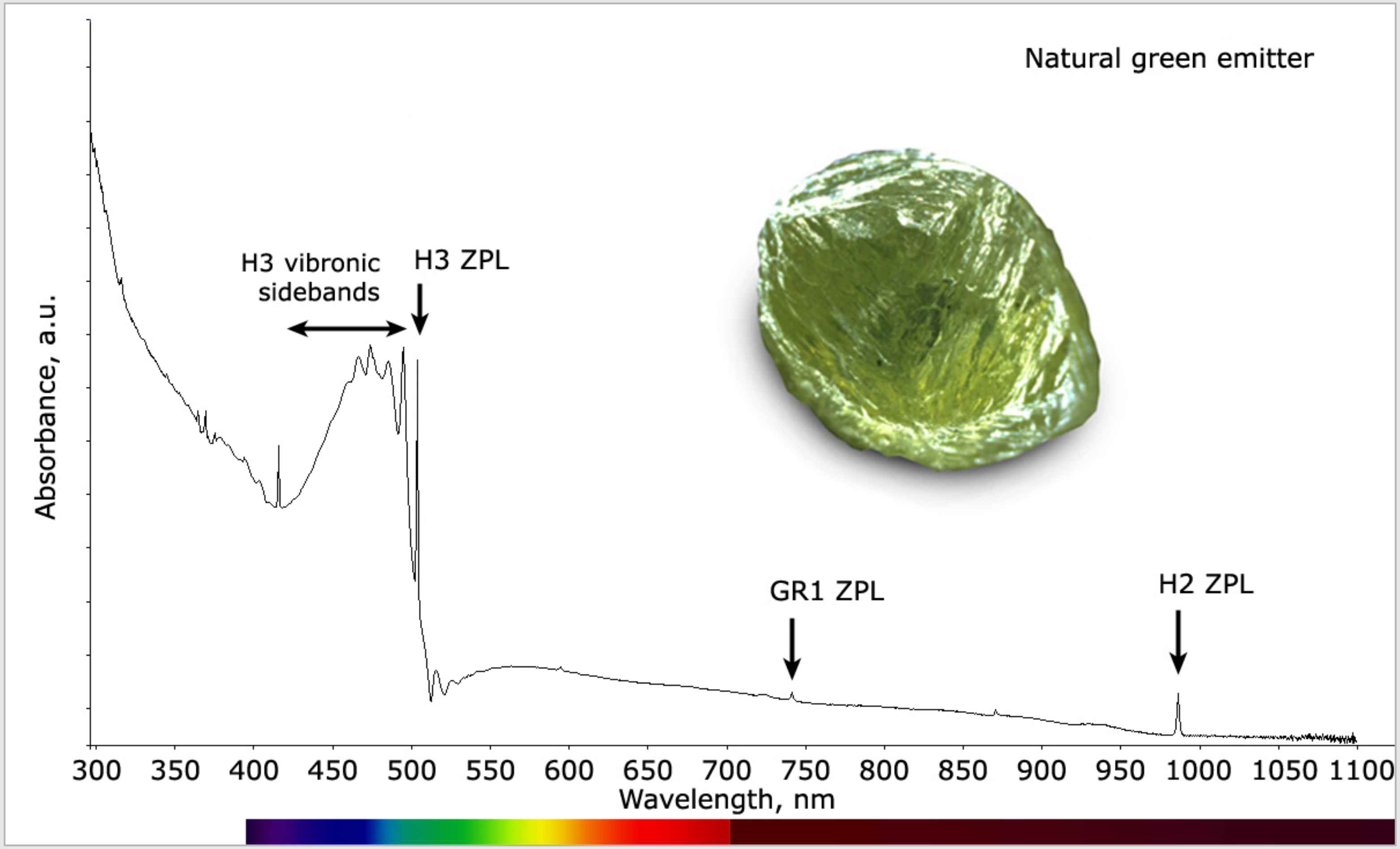




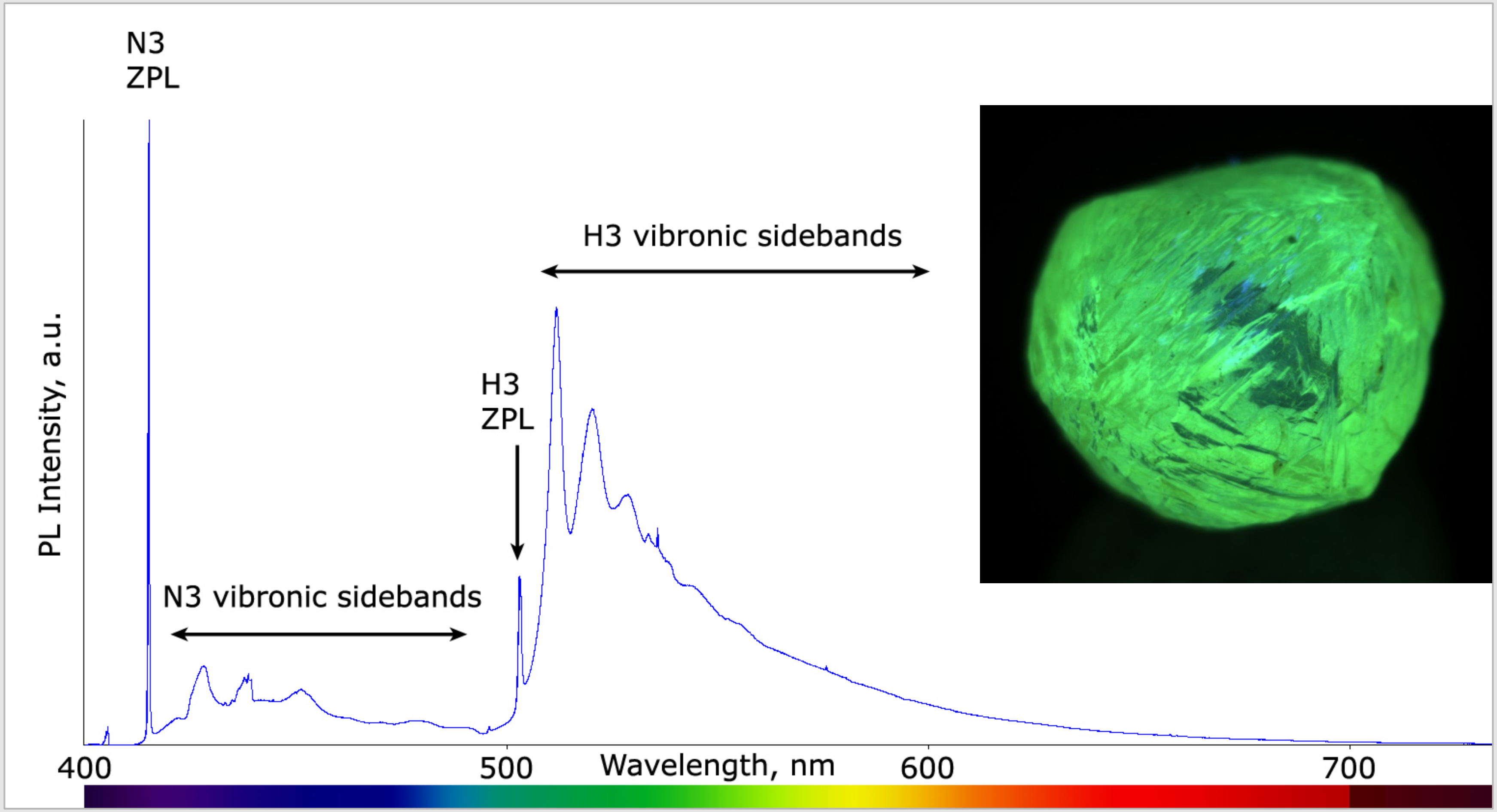


Adapted from Bursill and Glaisher, 1985

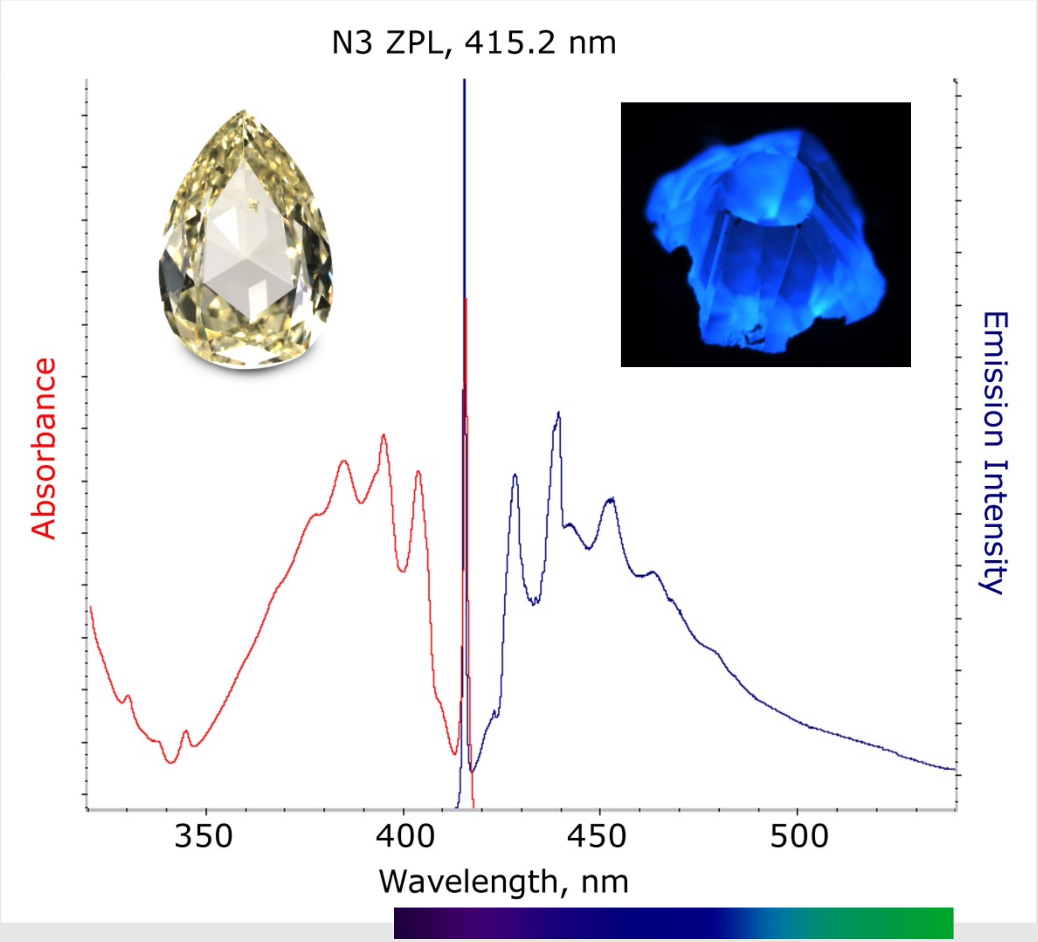
Absorption by H3 defect: yellow color



Emission by H3 defect: green luminescence

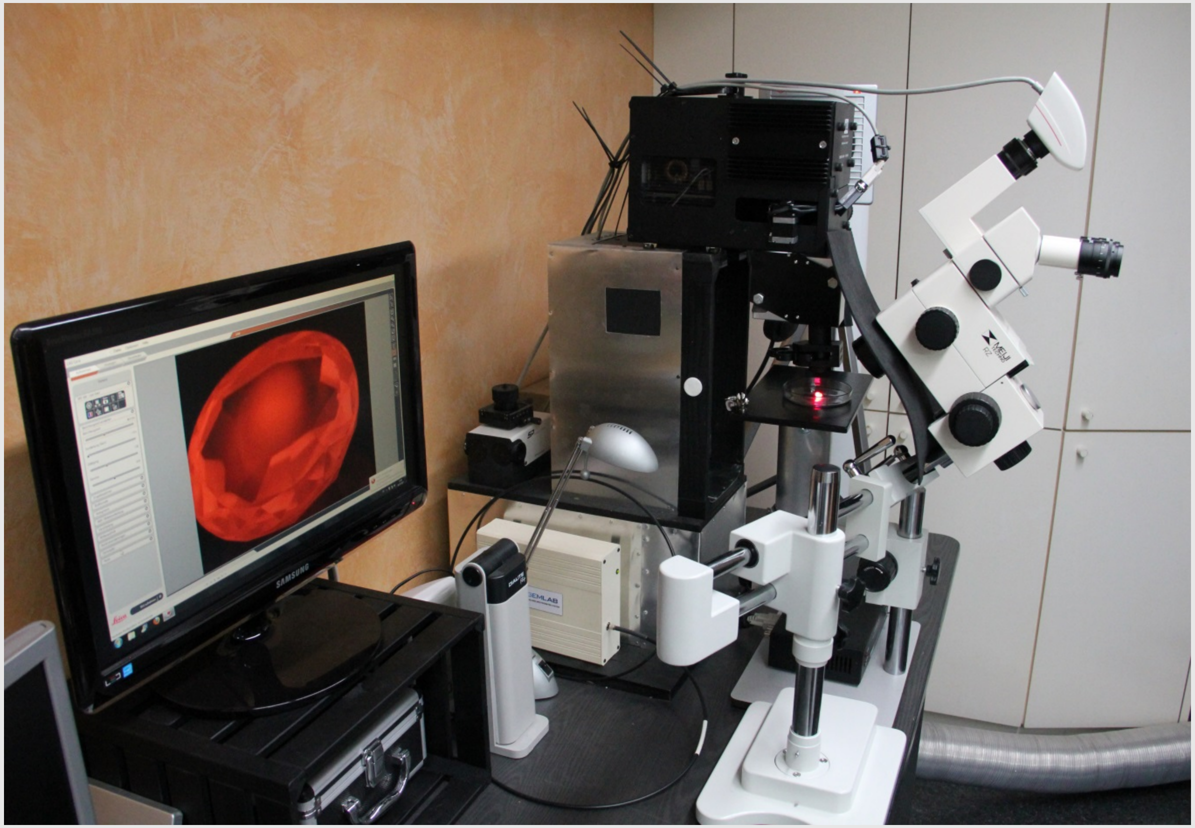


Absorption vs Emission

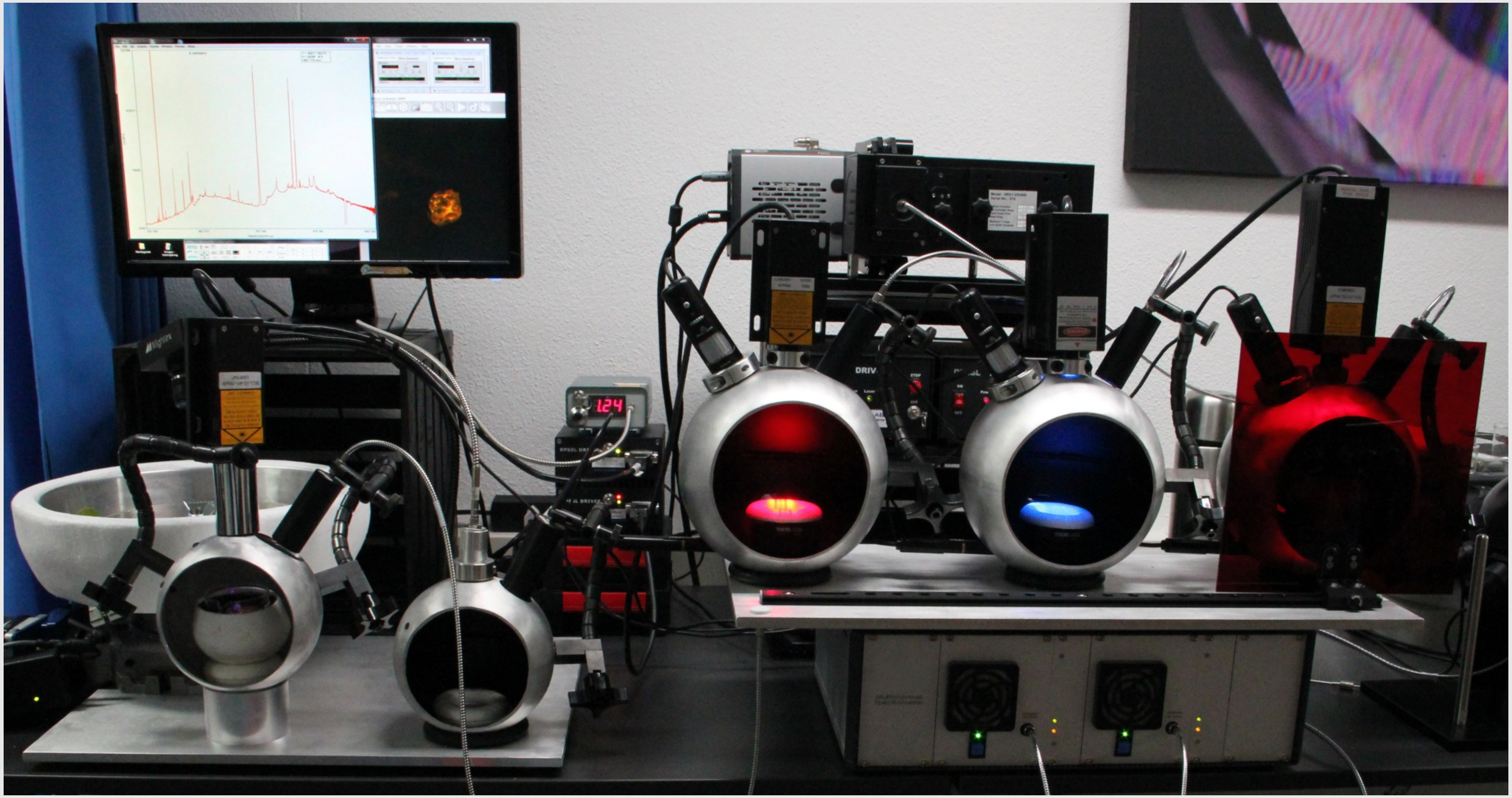


Modern tools to excite and measure luminescence

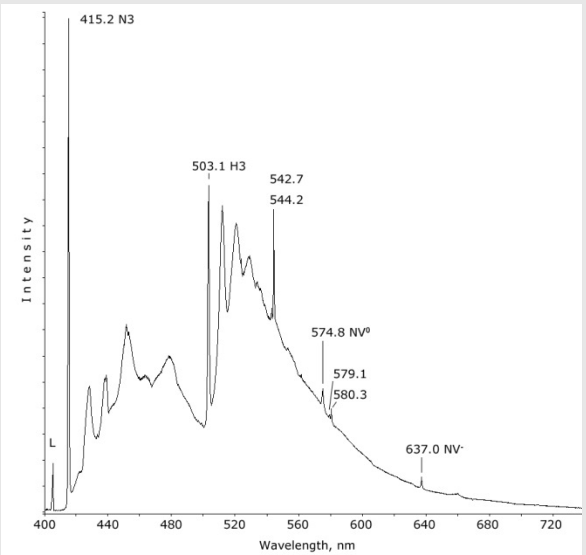
Fluorescence microscopy

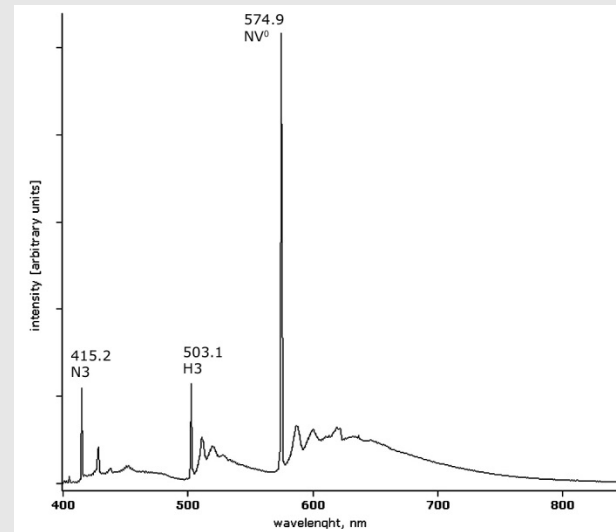


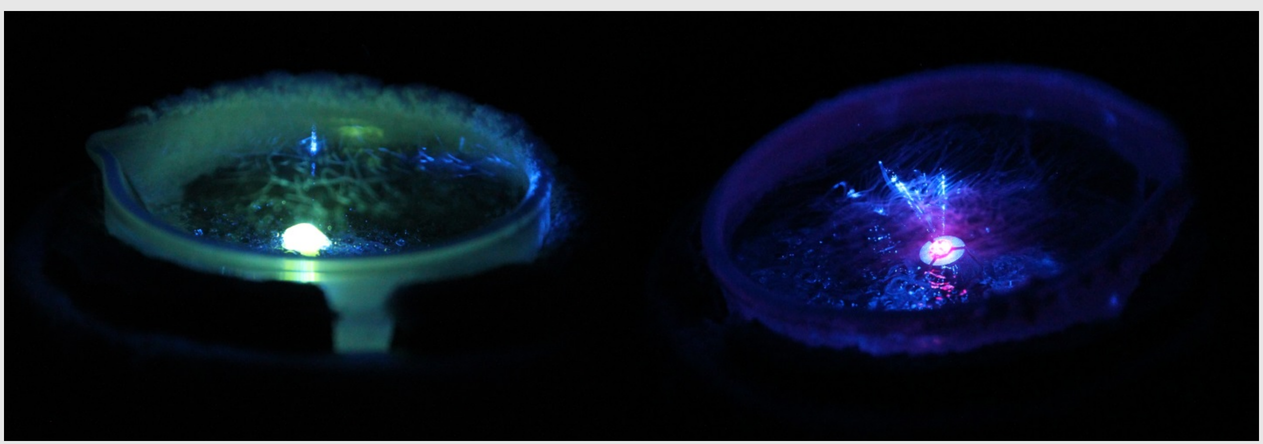
Photoluminescence spectroscopy

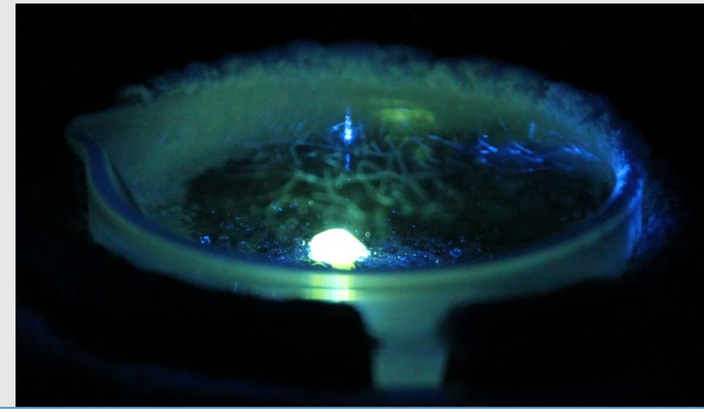


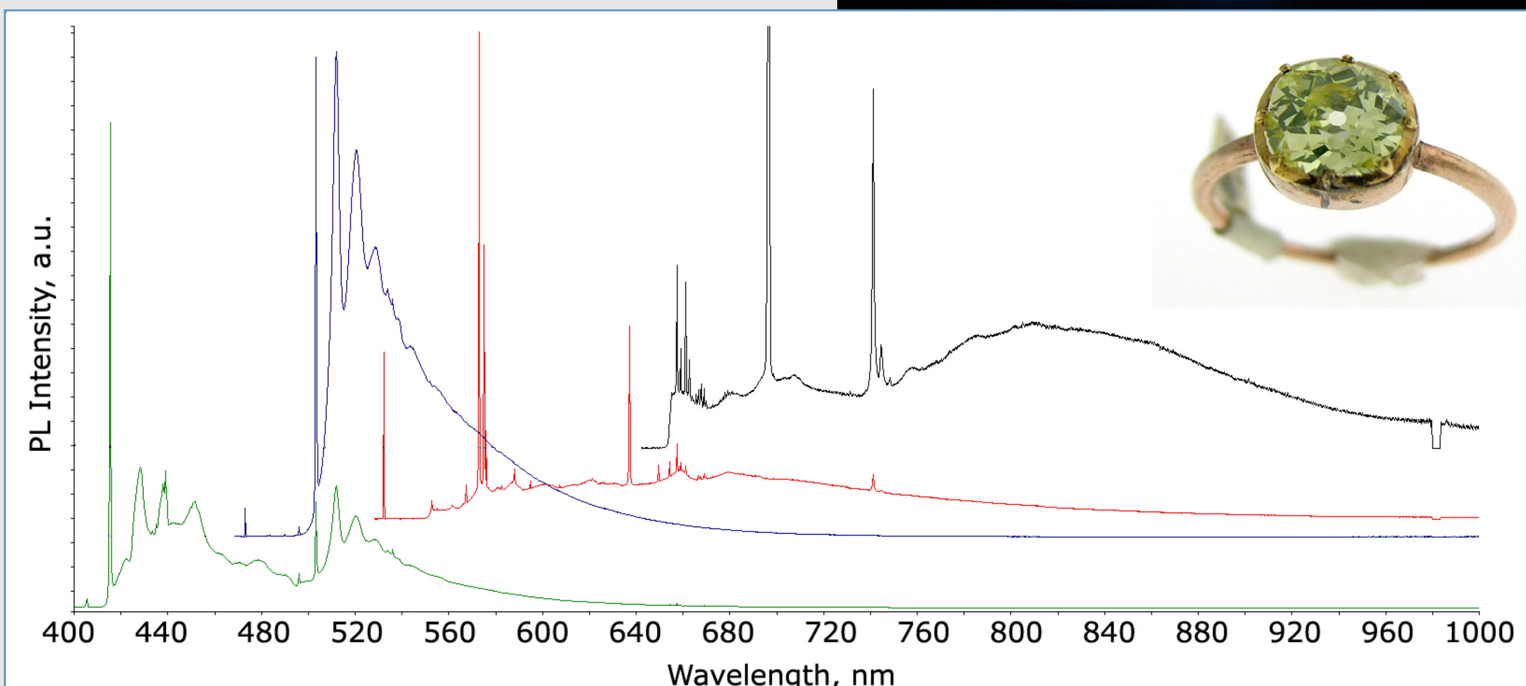
Low temperature photoluminescence spectroscopy

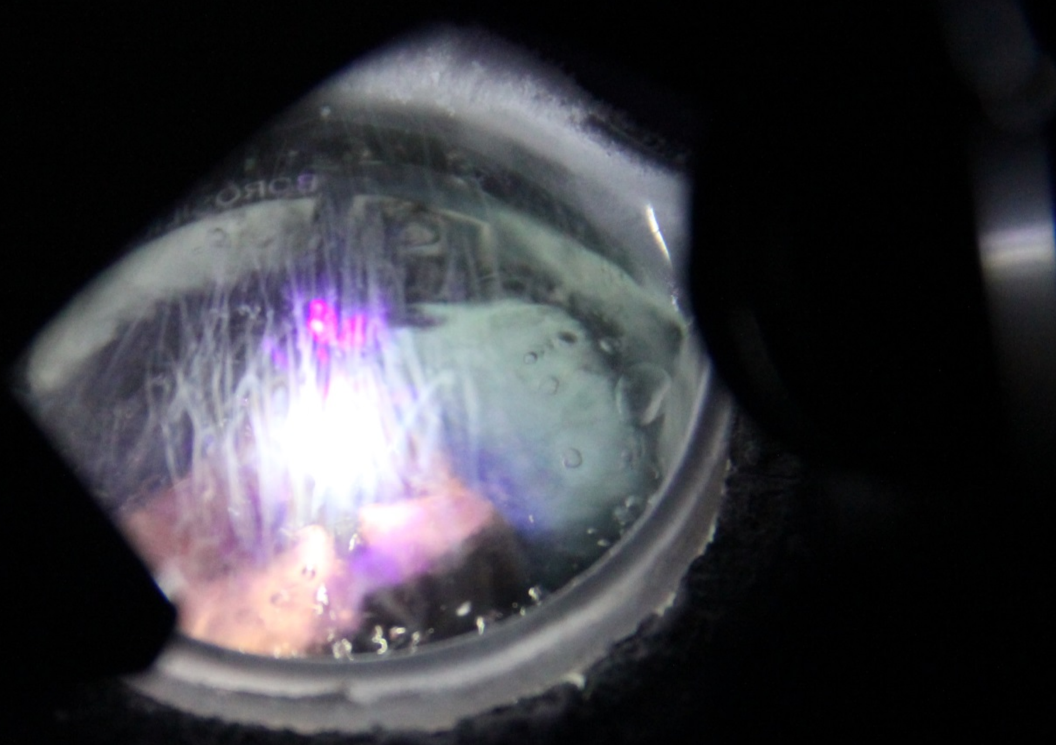








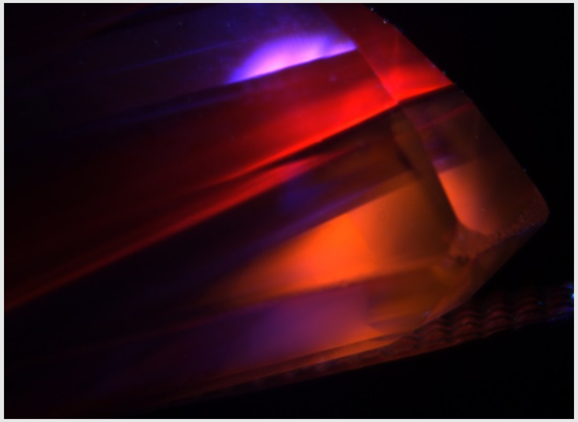

PL Intensity, a.u.
400
440
480
520
560
600
640
680
720
760
800
840
880
920
960
1000
Wavelength, nm

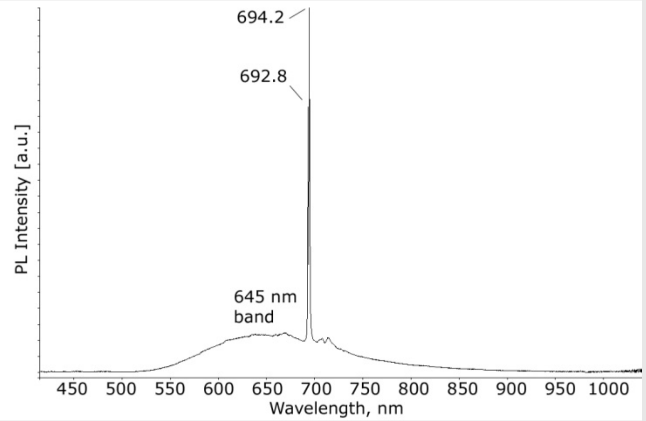


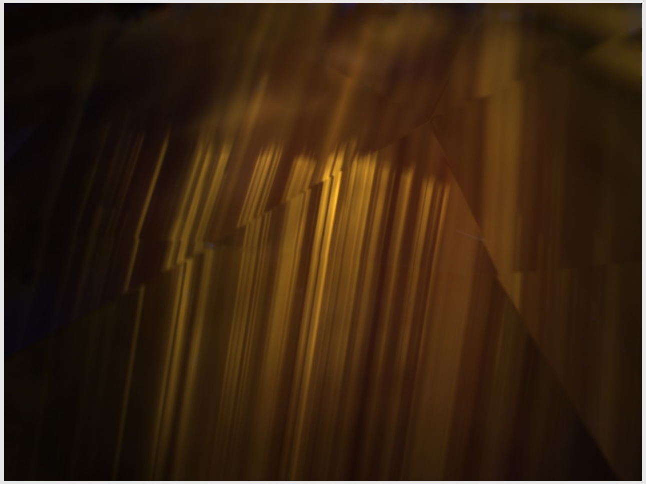
Applications of luminescence techniques in gem testing

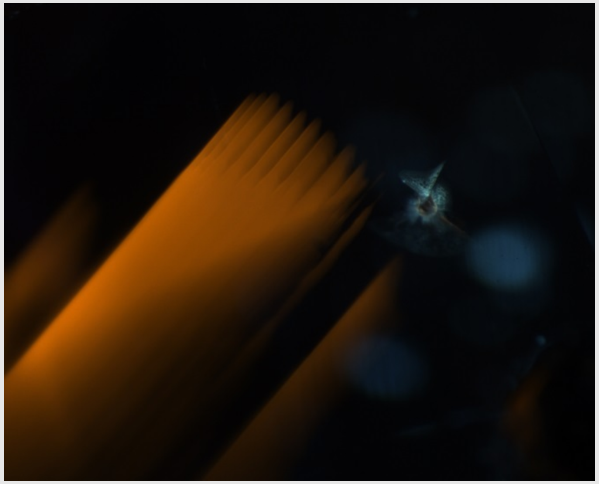
Corundum: ruby and sapphire

Natural sapphire: red + yellow PL





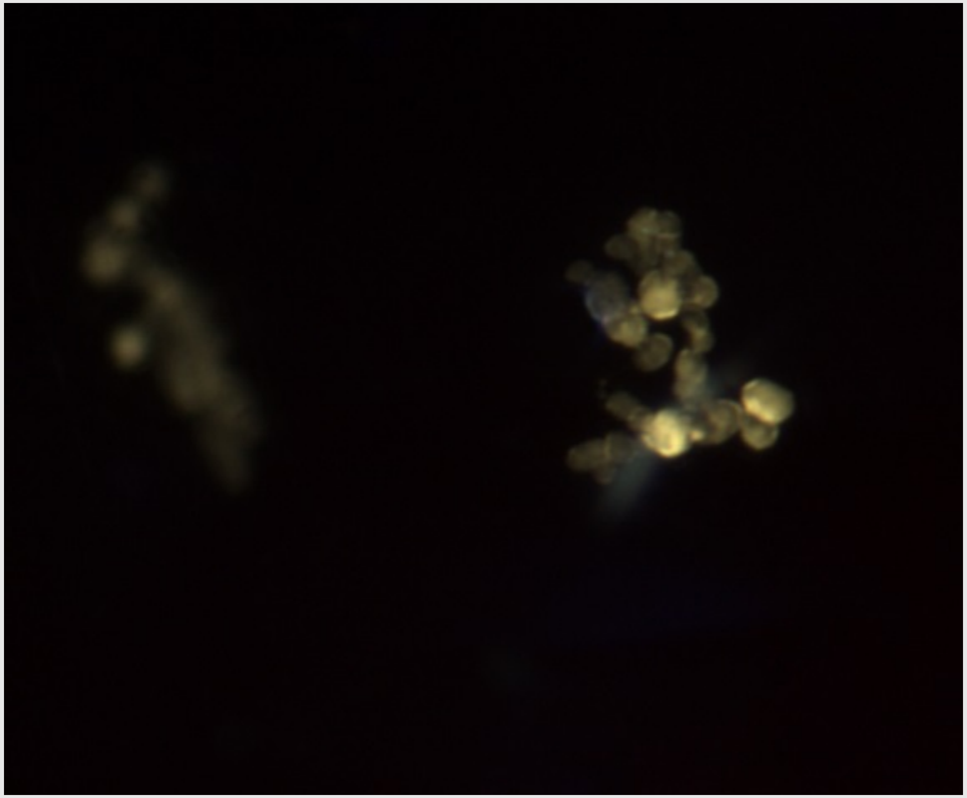


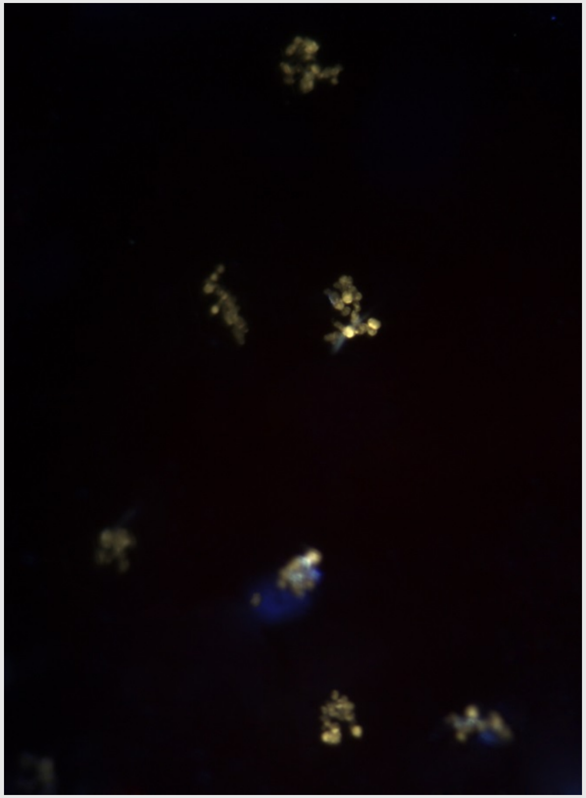


Red: Cr3+

Yellow: trapped hole defect.

Luminescent inclusions in sapphire

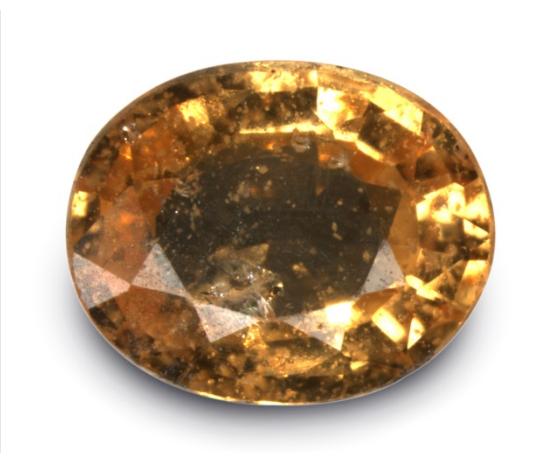


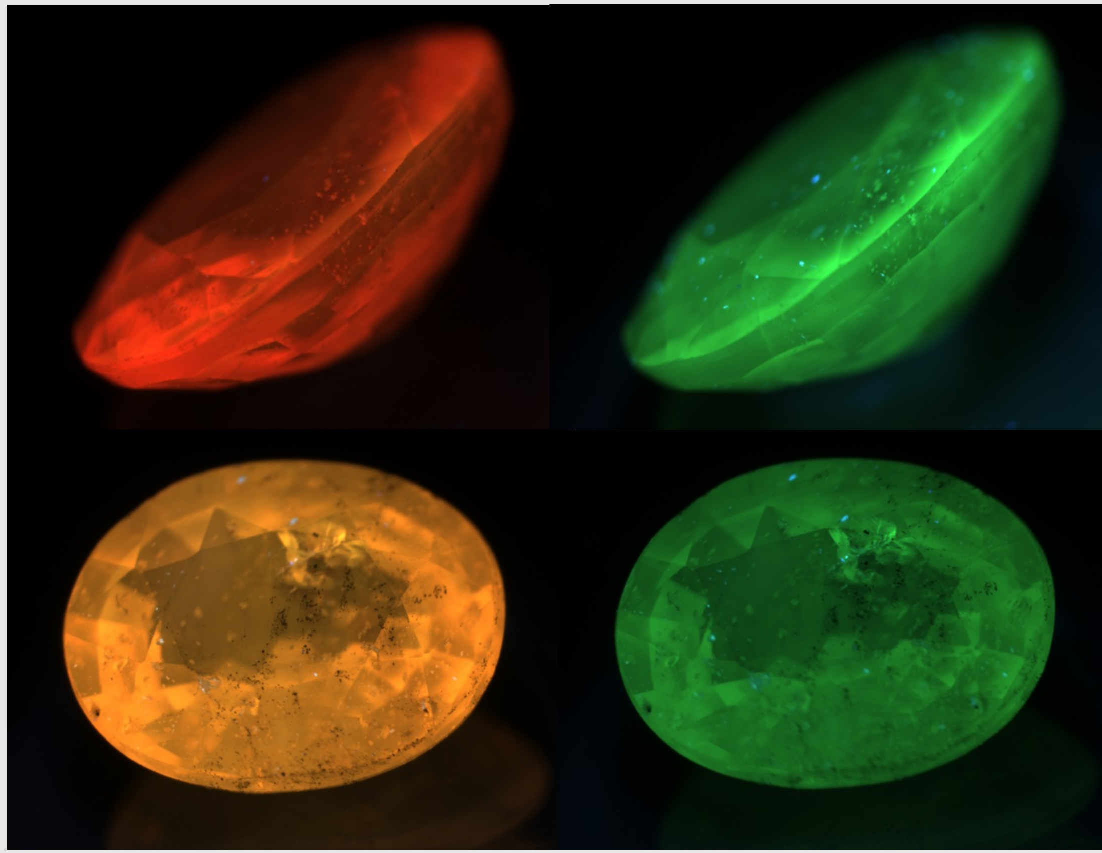


Heat treated metamorphic sapphire

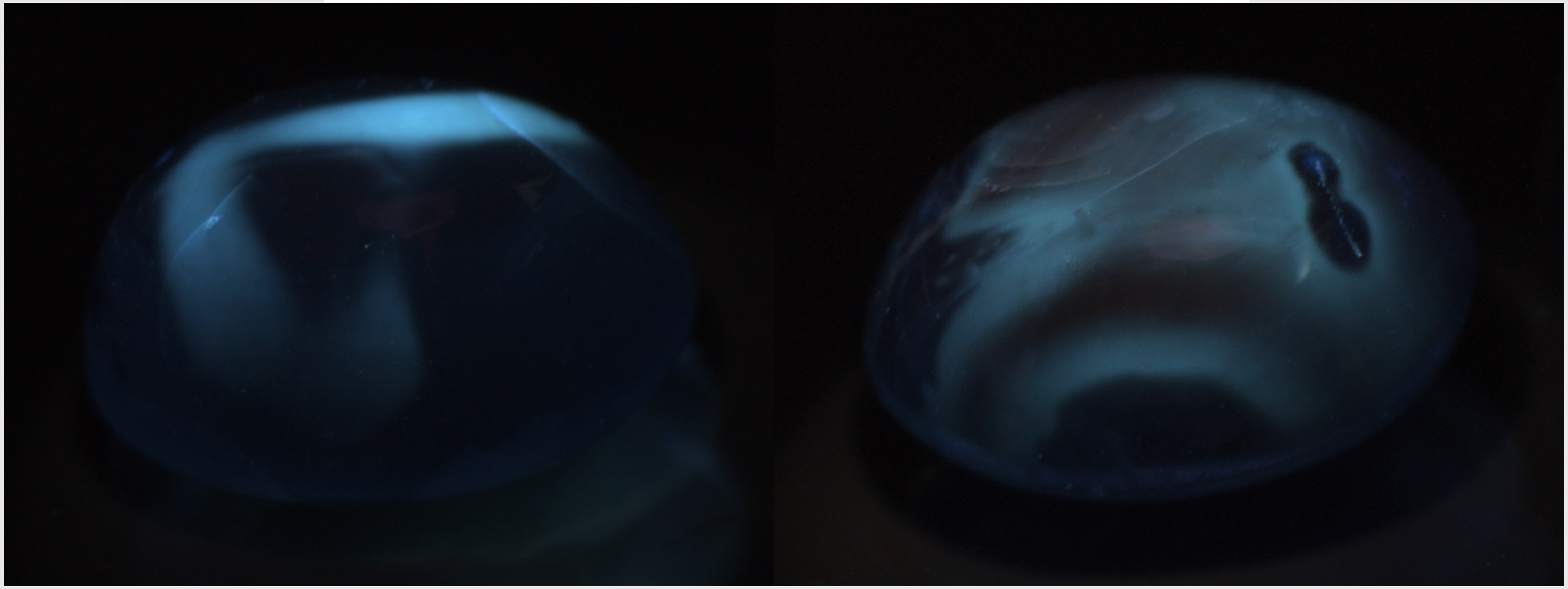
Titanate-related chalky blue white PL under short wave UV

Heat treated sapphire, with Be (Be diffusion)

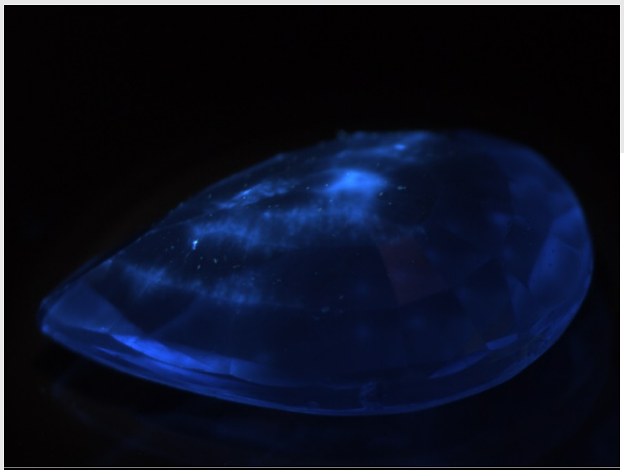
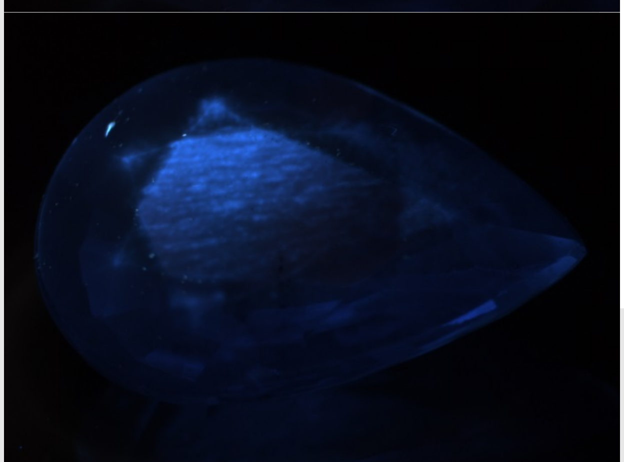


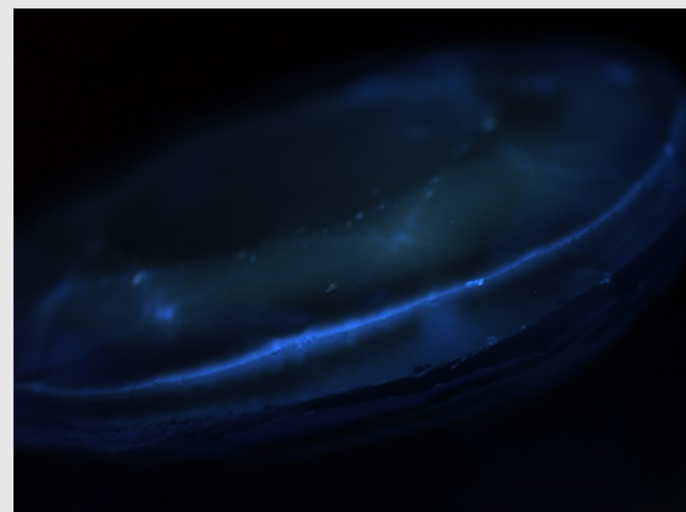


Beryllium diffused blue sapphire

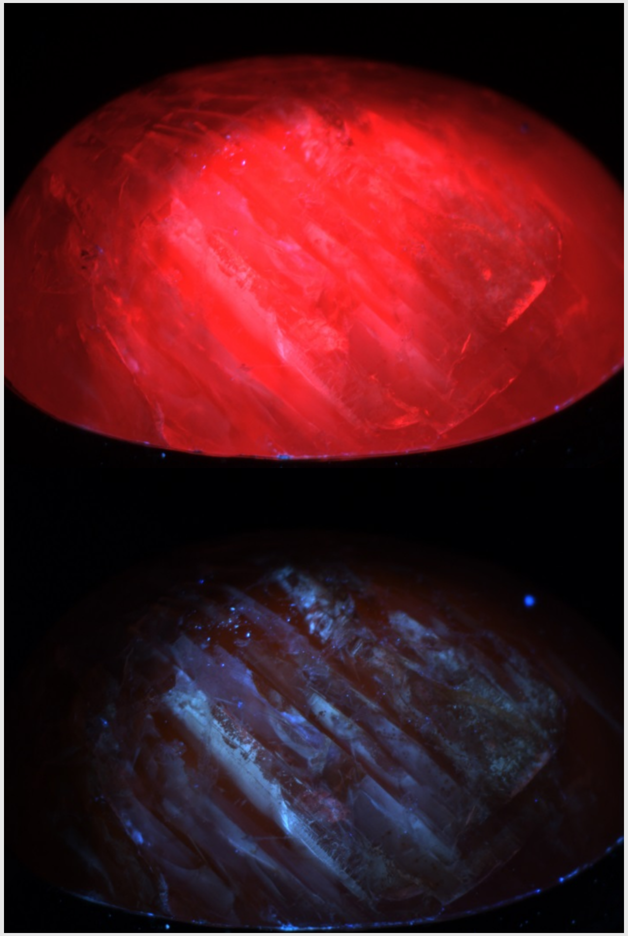


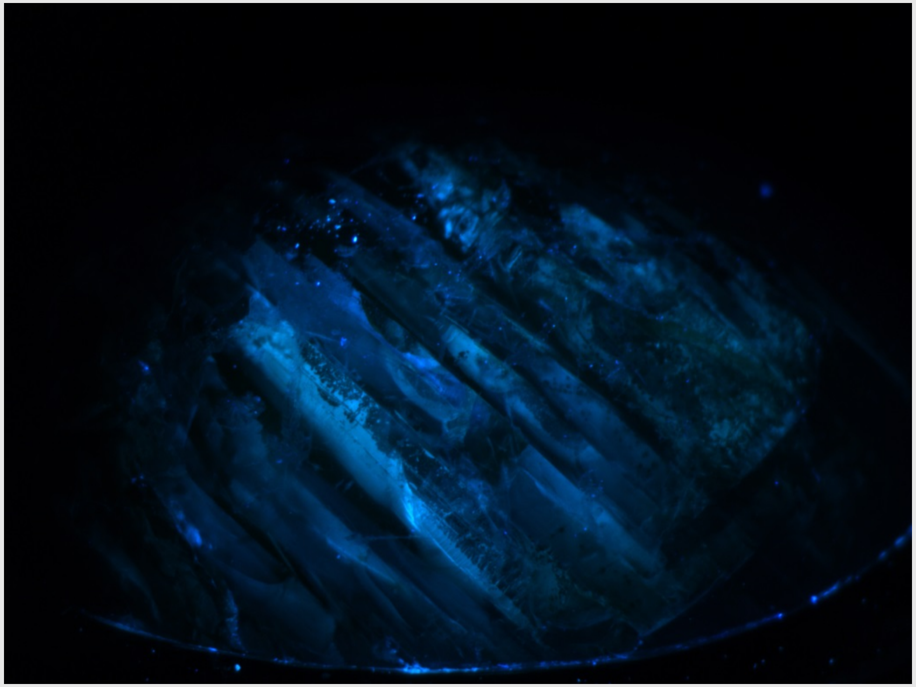
Titanium diffused blue sapphire

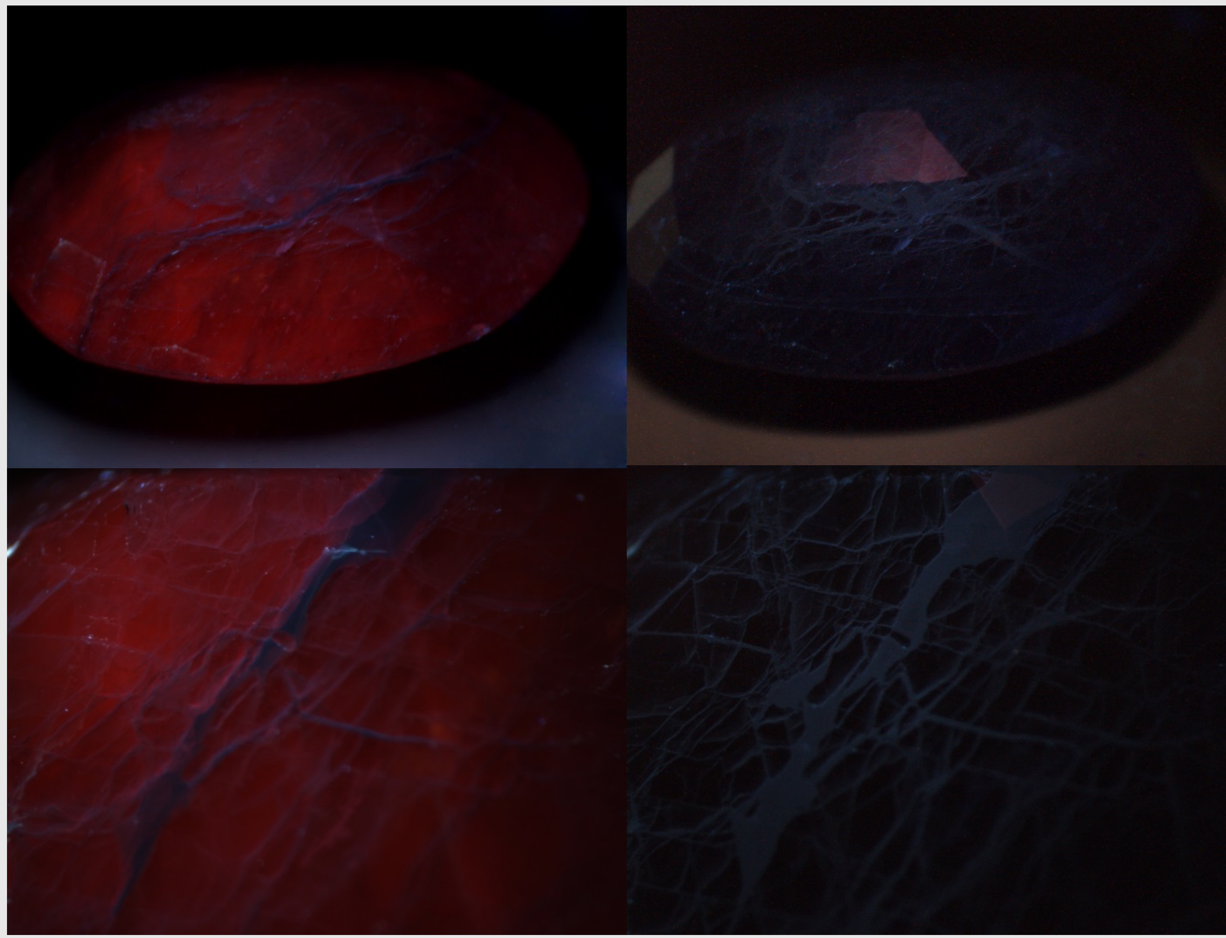



Oiled ruby (clarity enhanced)

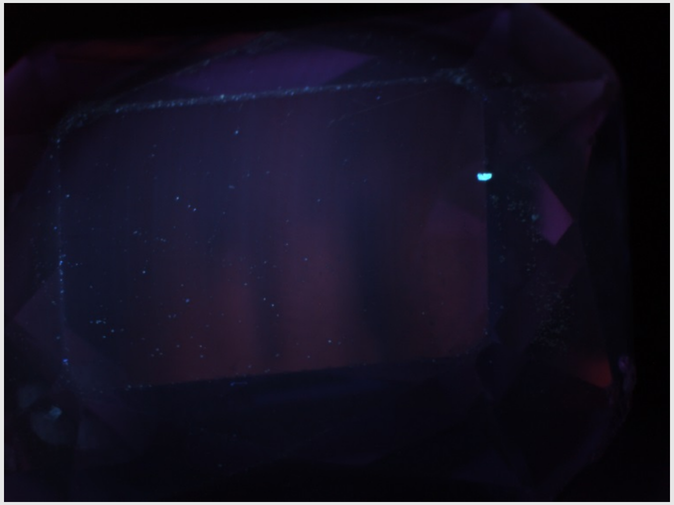


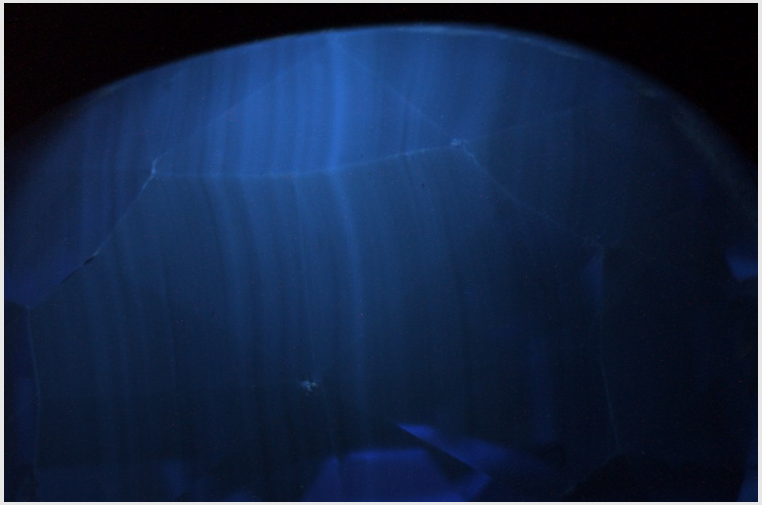


Lead glass treated ruby



Flame fusion synthetic sapphire

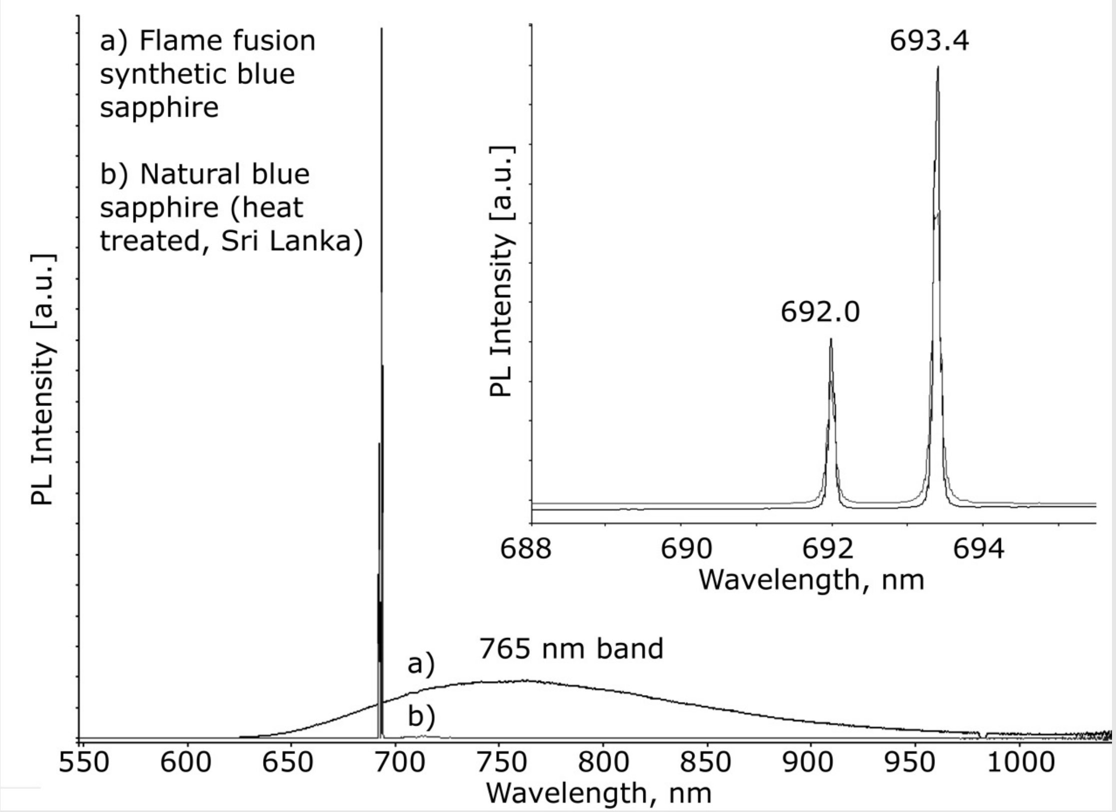




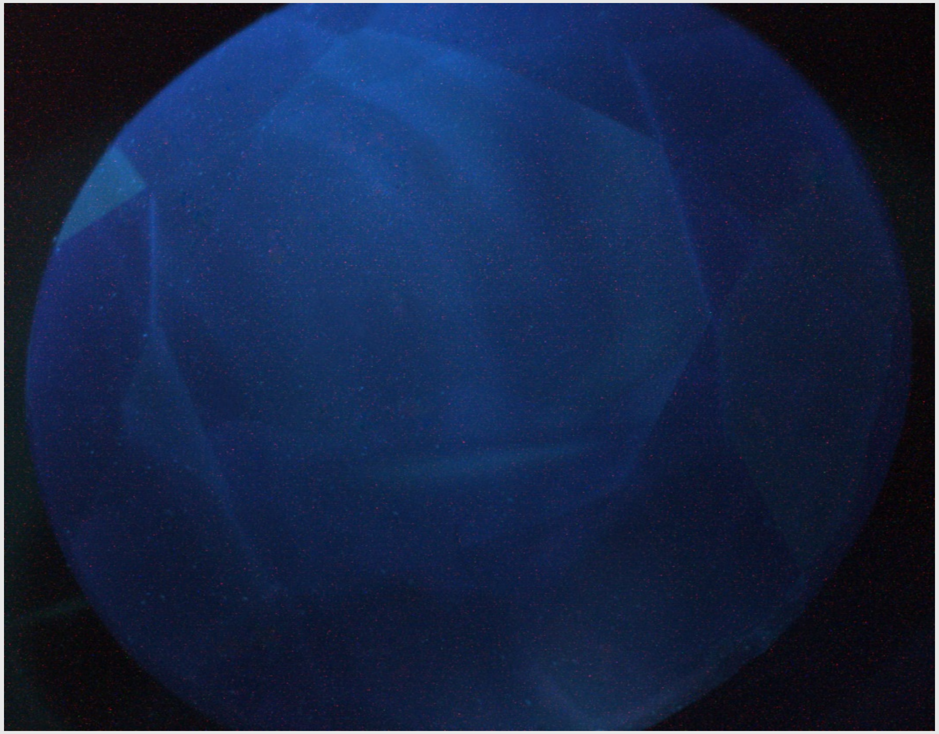
Natural vs flame fusion synthetic sapphire: PL spectroscopy

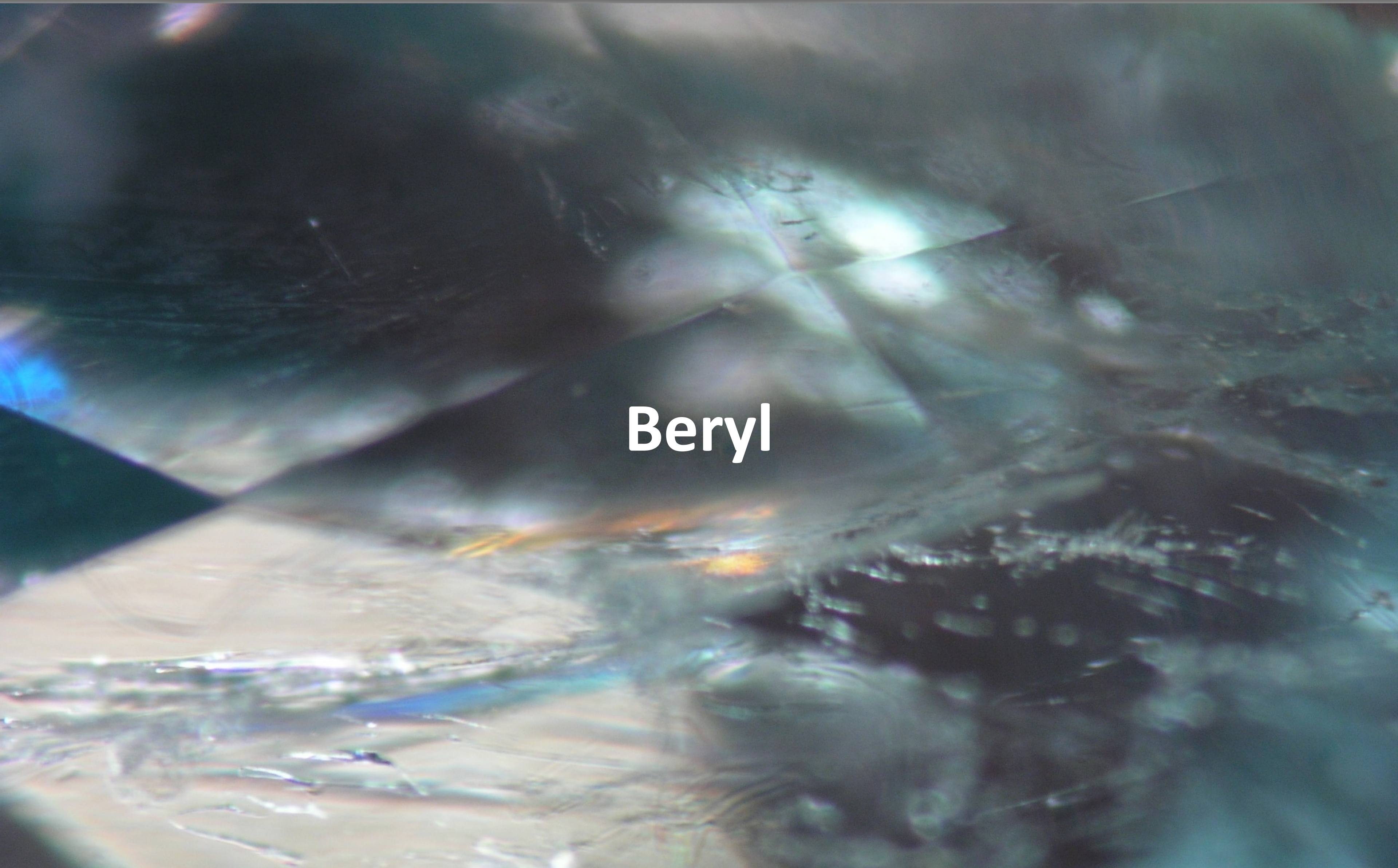
a)

b)

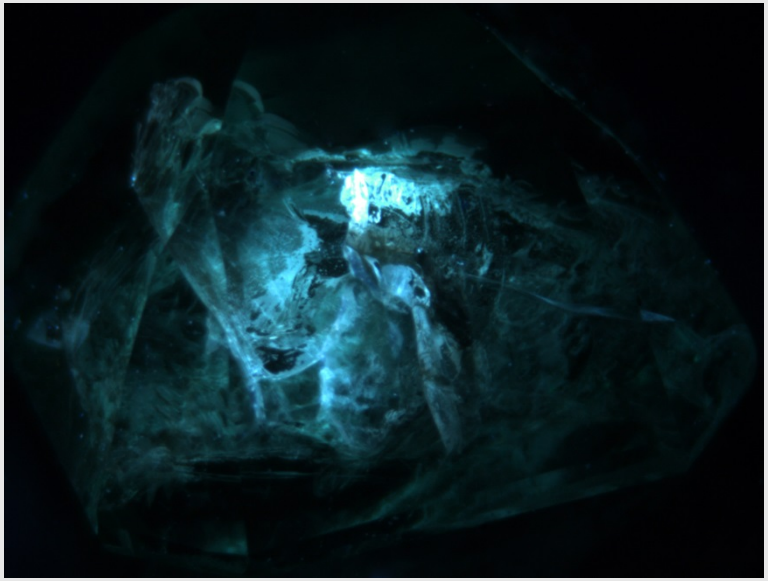


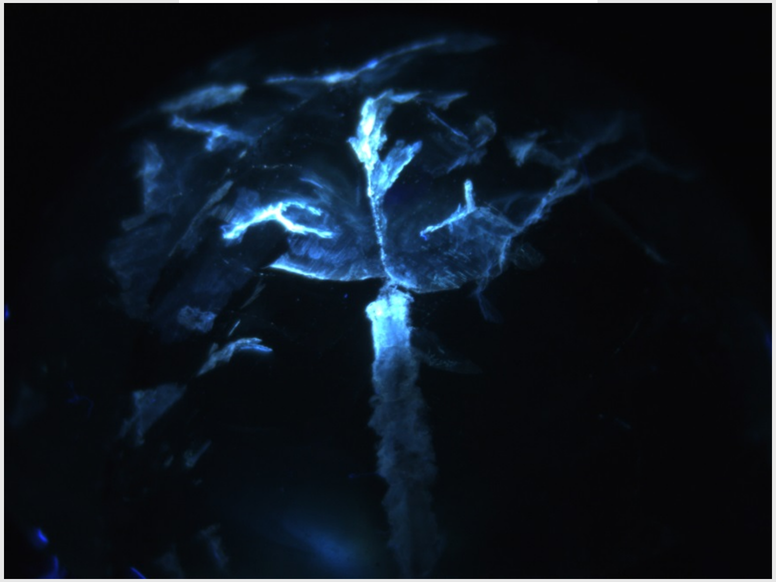
Flame fusion synthetic ruby



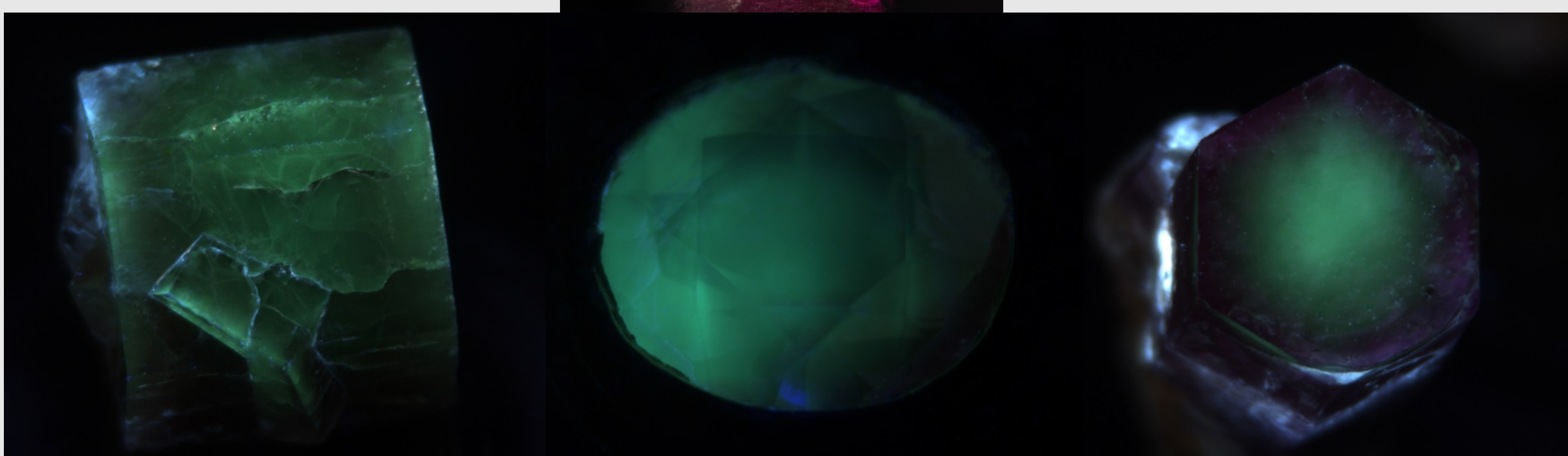

Beryl

Clarity enhanced emeralds: oils and resins

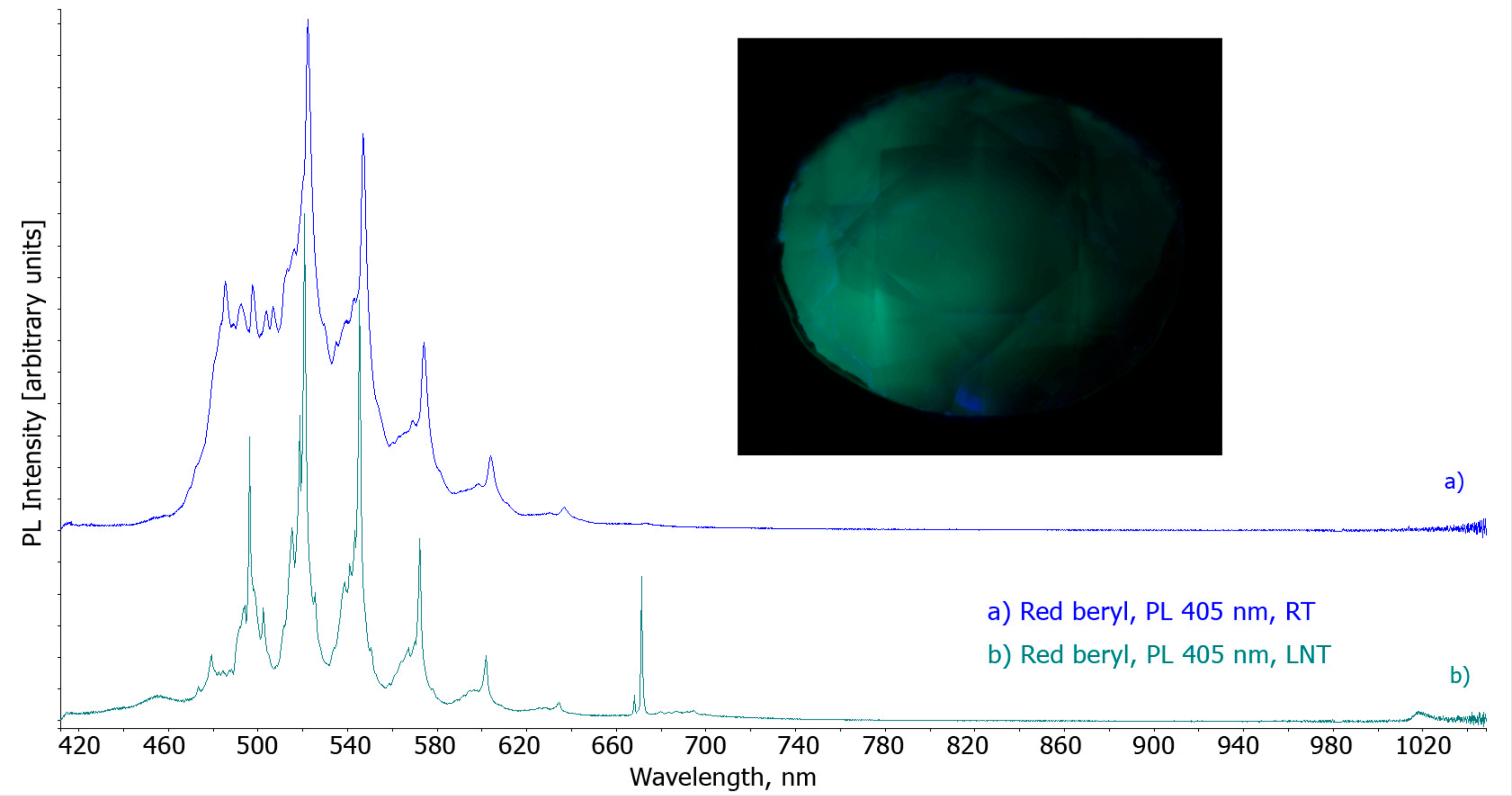




Red beryl: Uranium related green PL

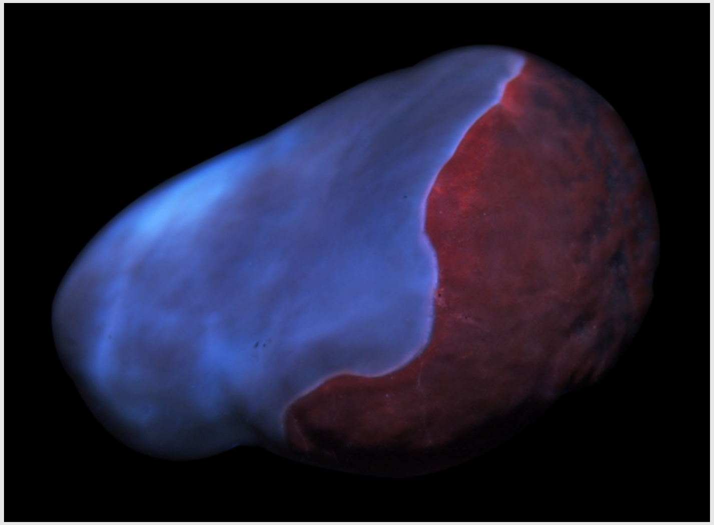


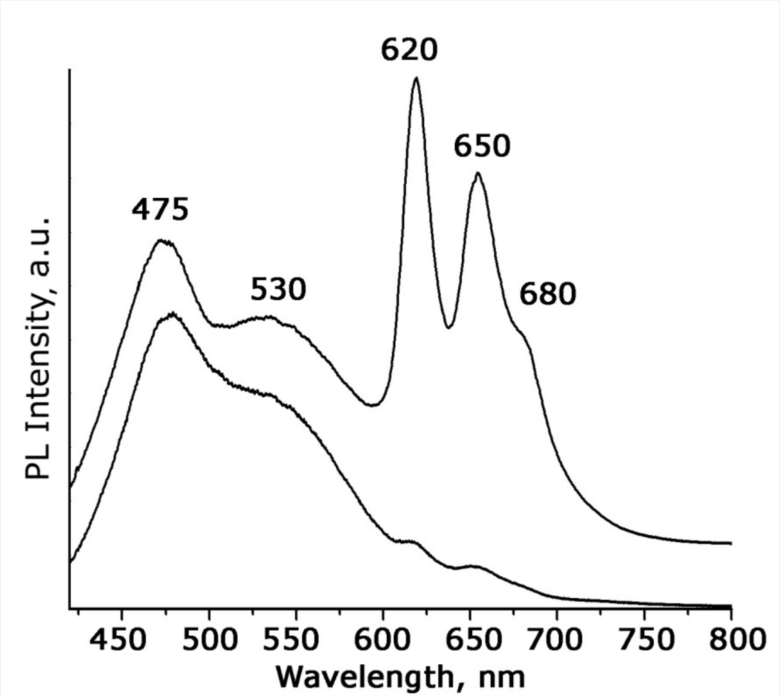
PL spectroscopy of red beryl: Uranyl emissions



Pearls

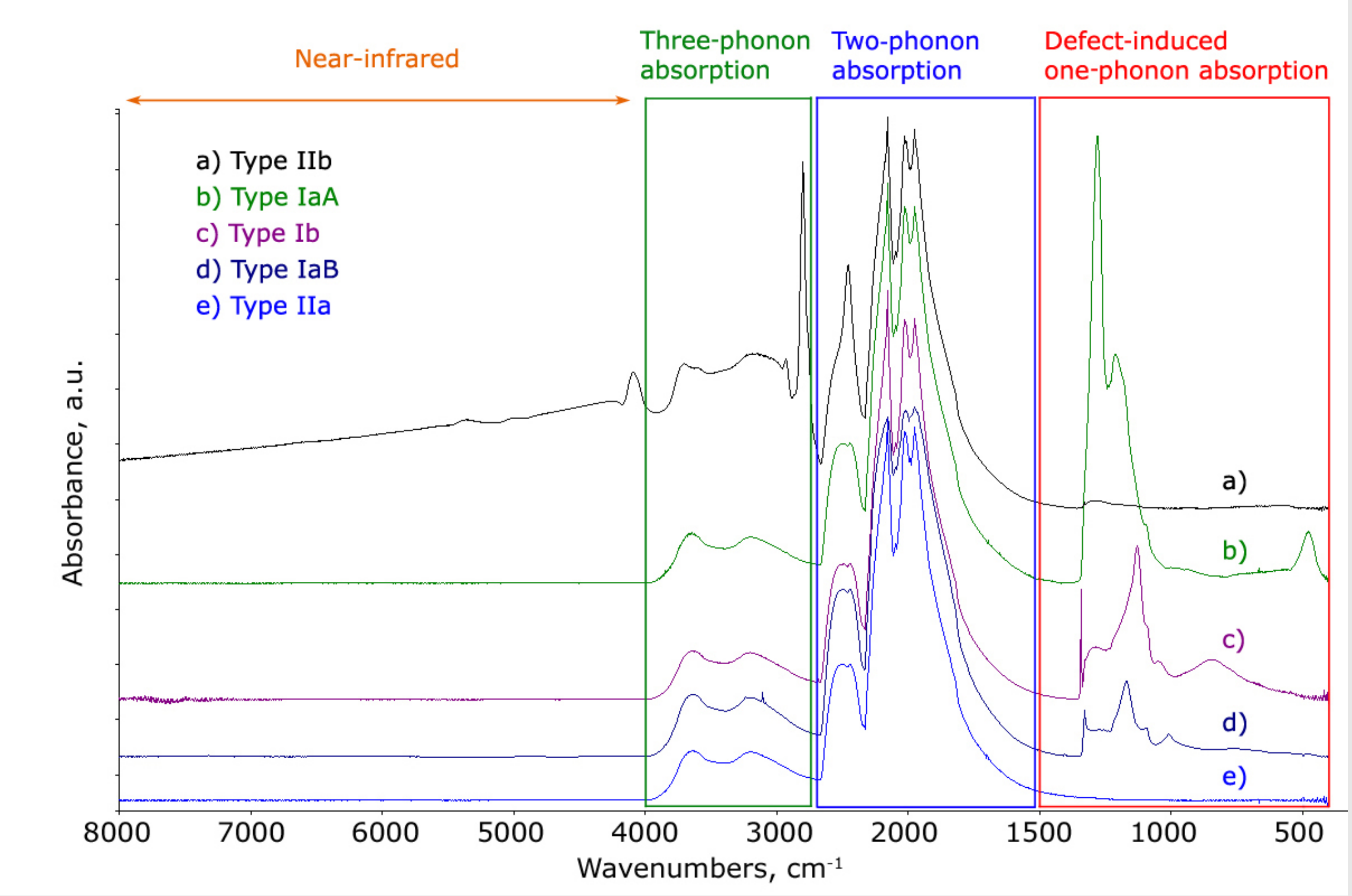
Pearls: red porphyrin-related PL



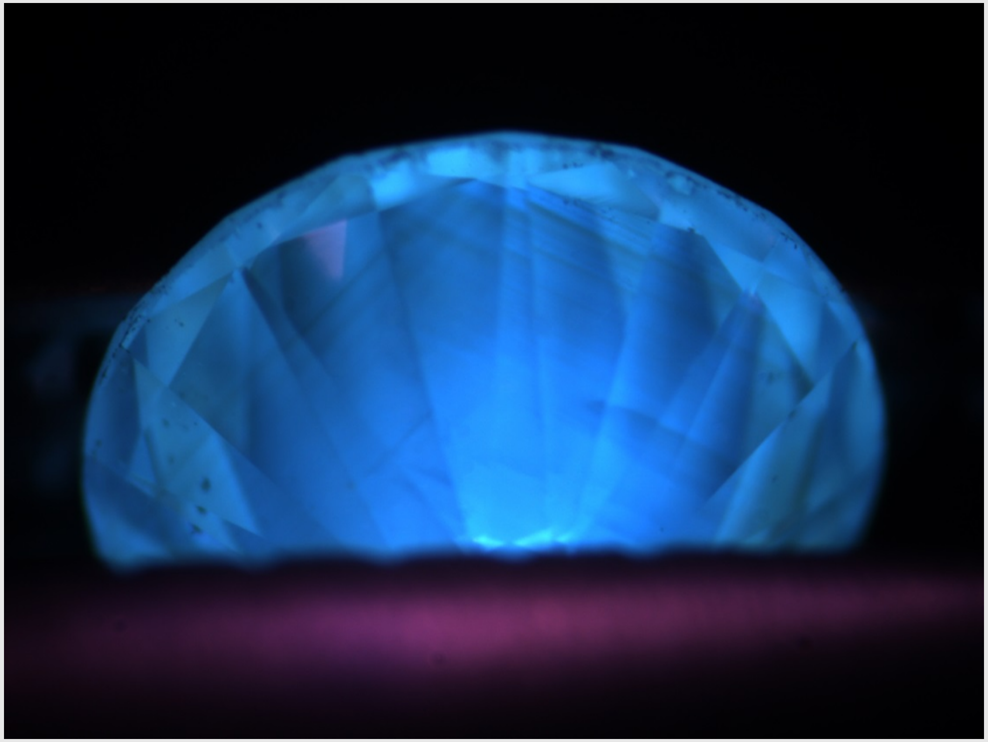


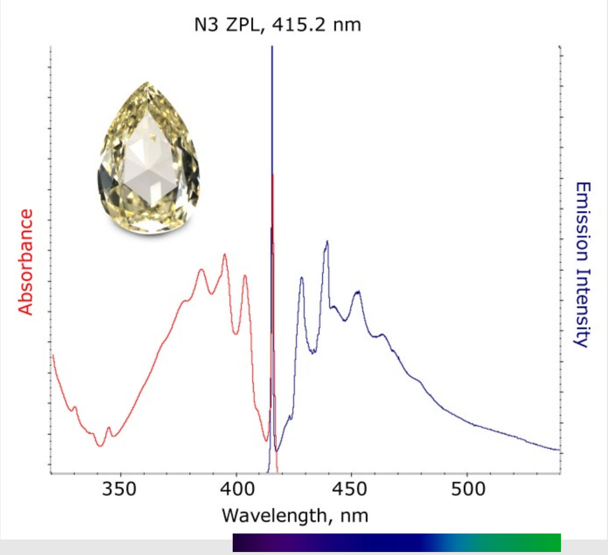
Diamonds

Short introduction into "type system"

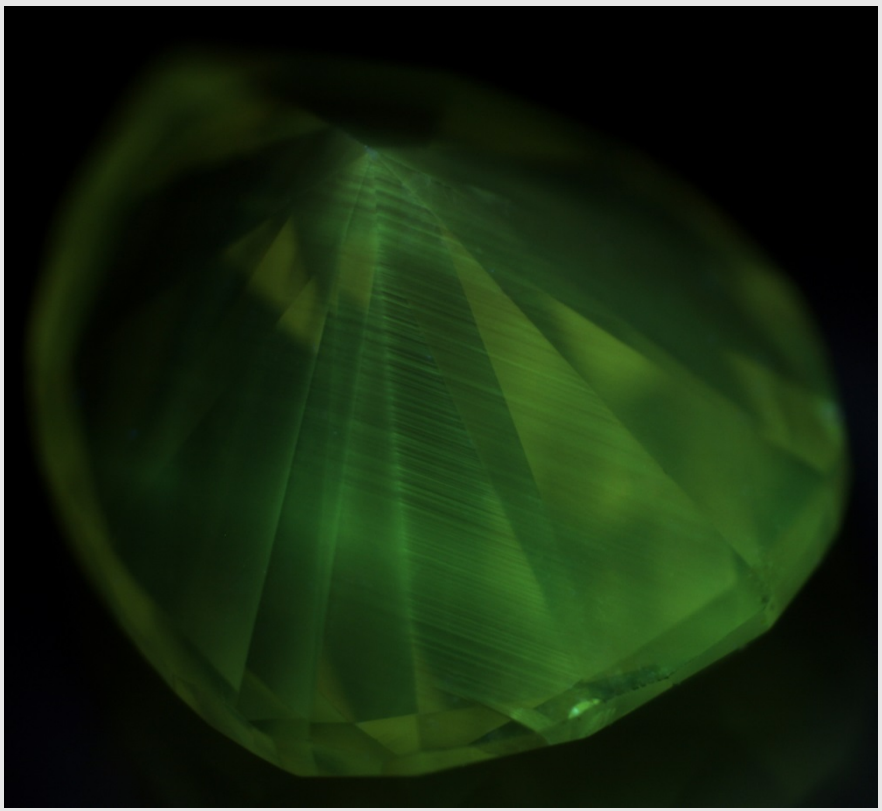


N3 center blue PL

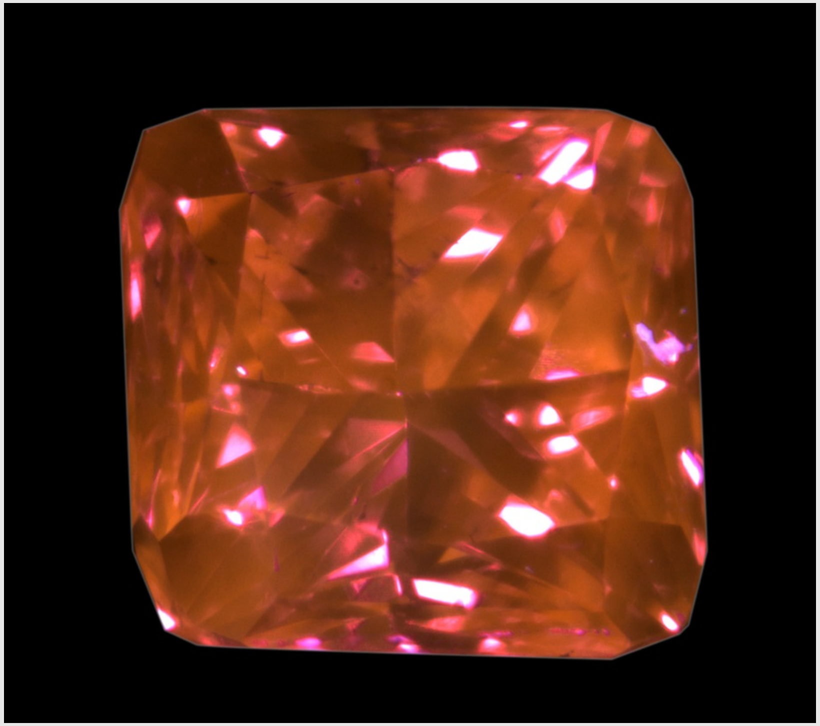


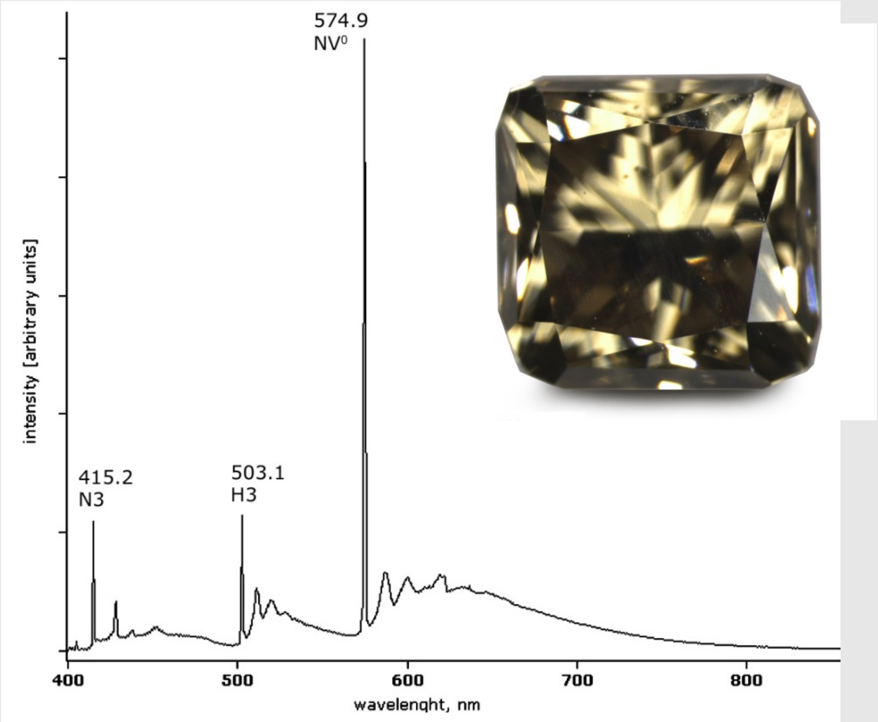


H3 center green PL

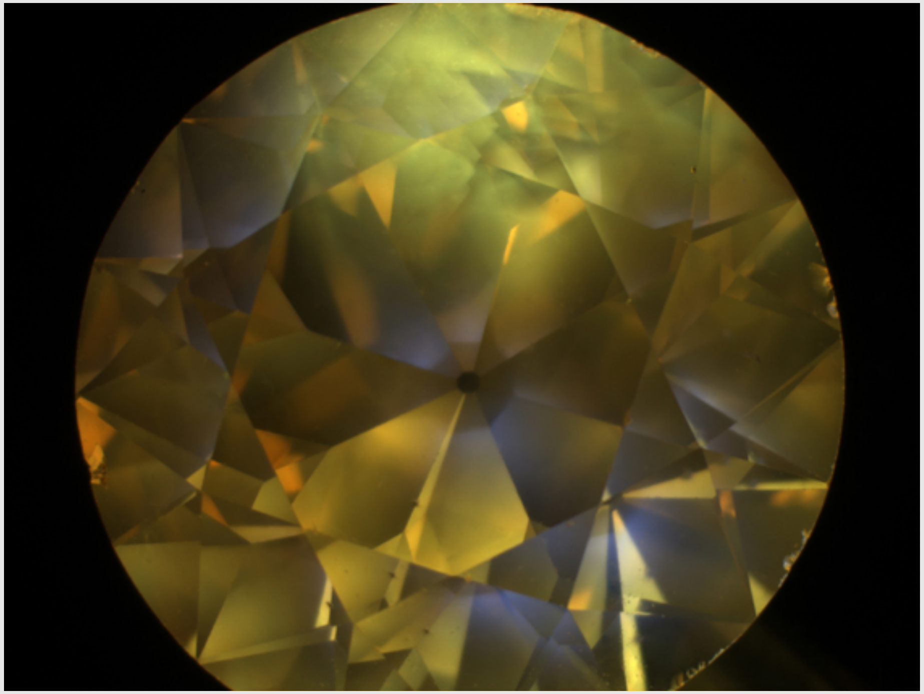


NV^0 center orange PL

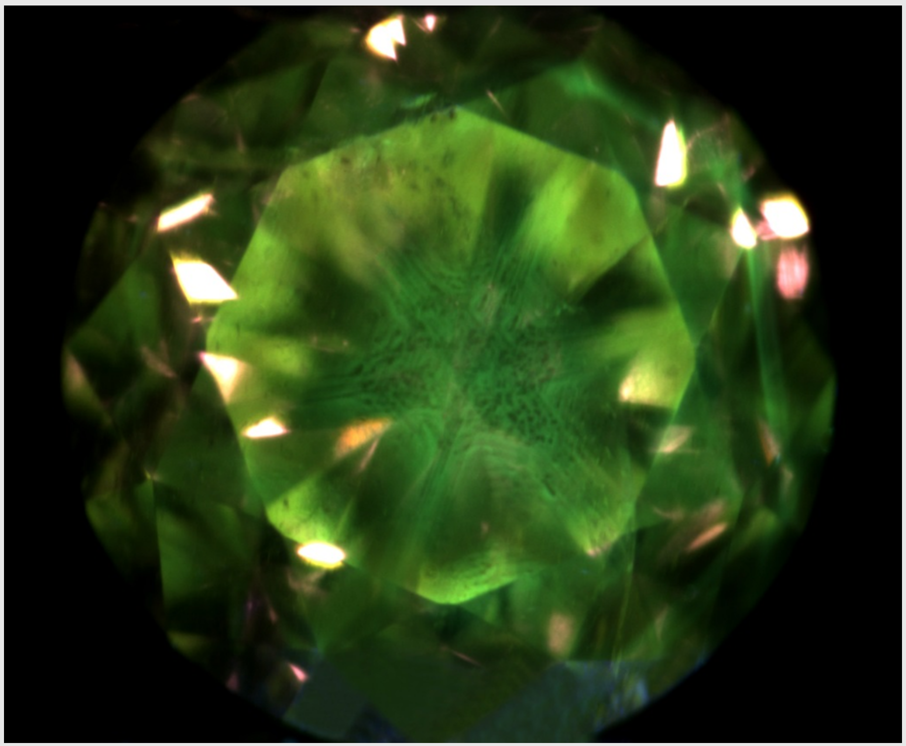


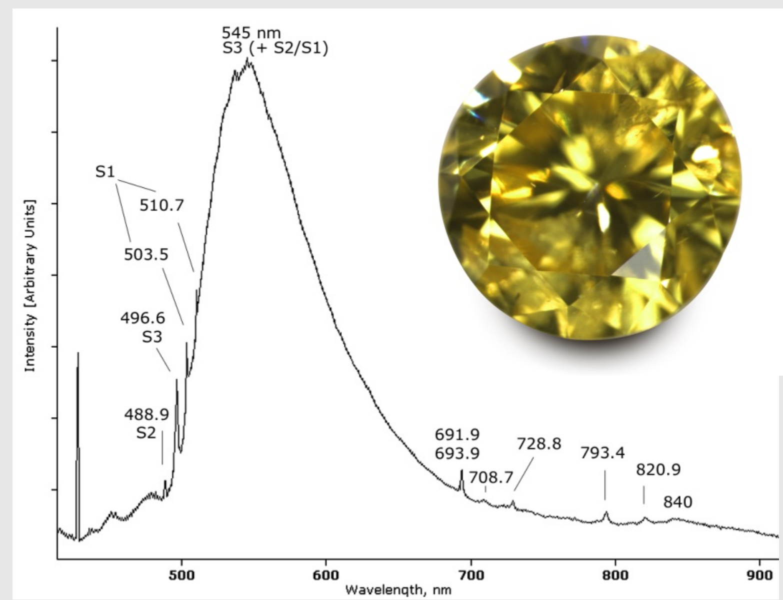


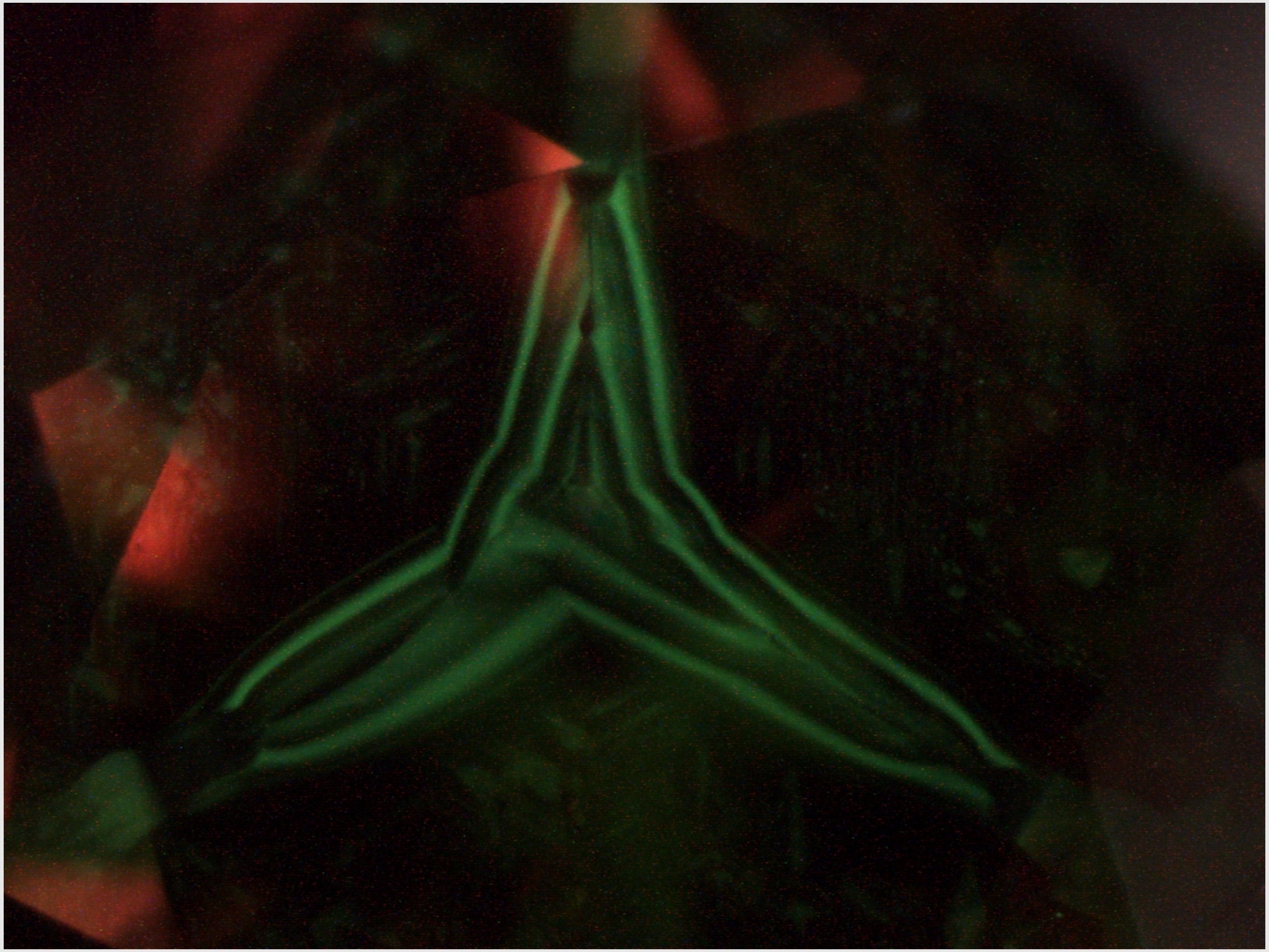
“480 nm band” diamonds

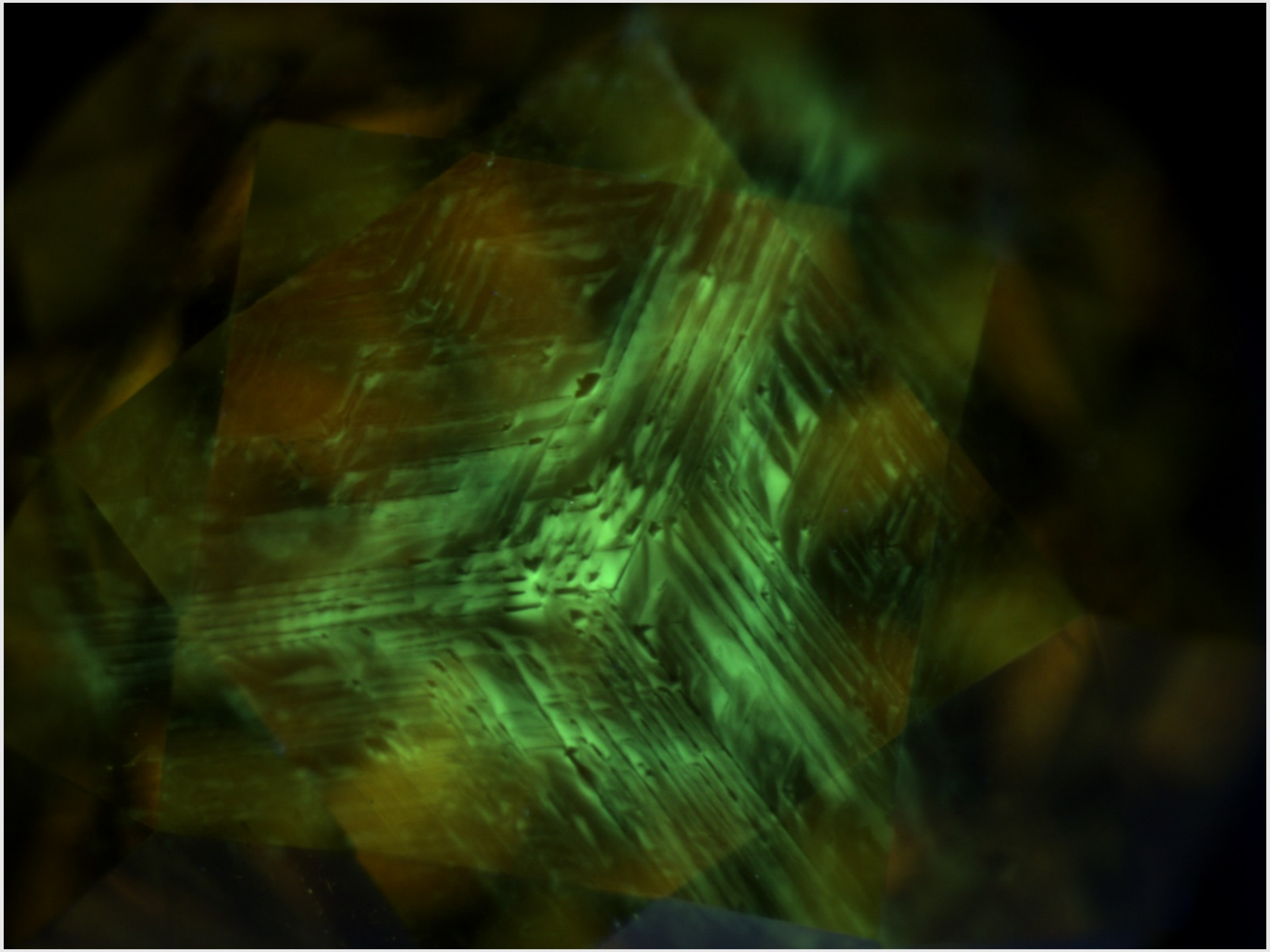


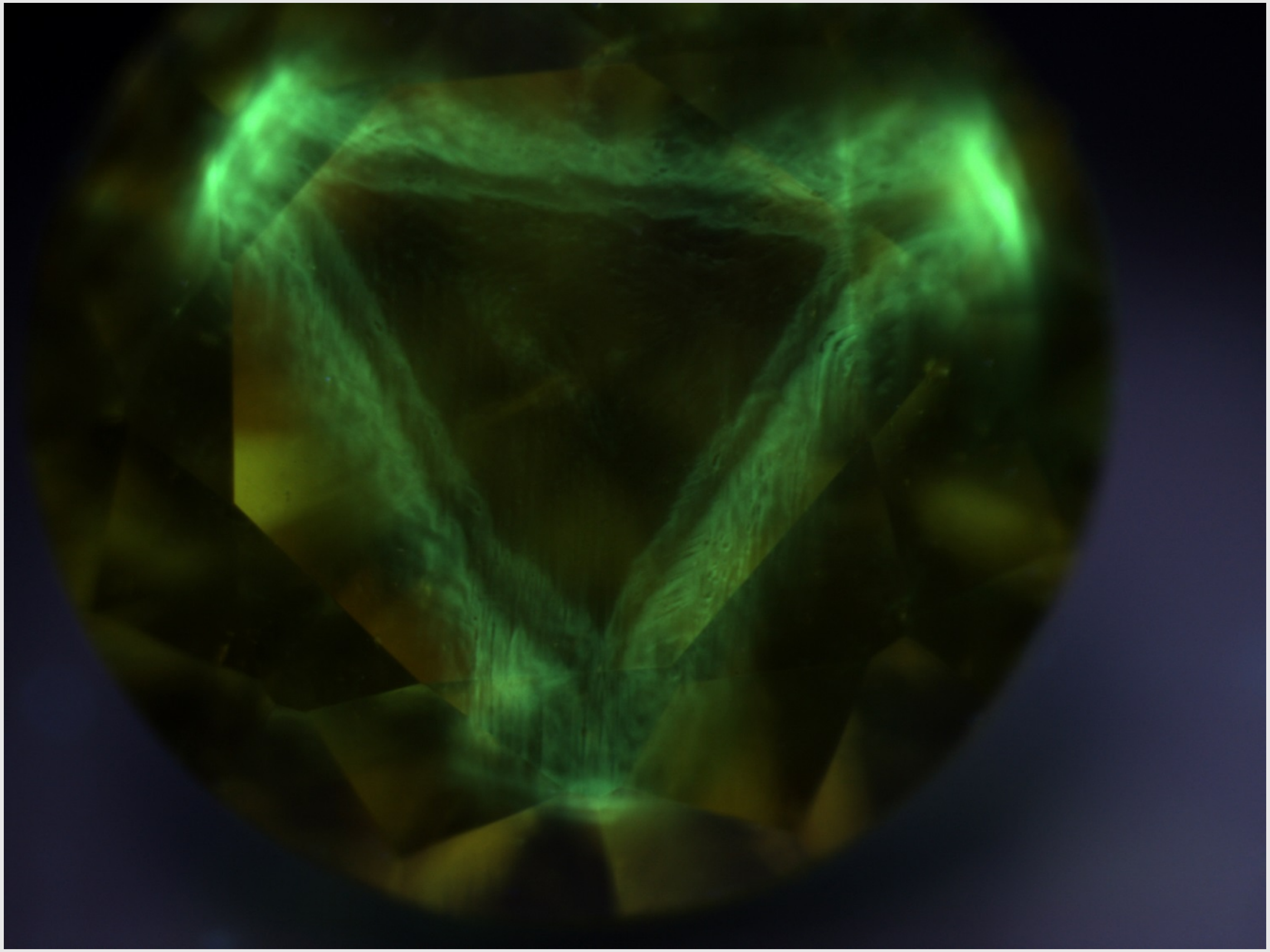
Green S3/S2/S1 PL: re-entrant cube diamonds

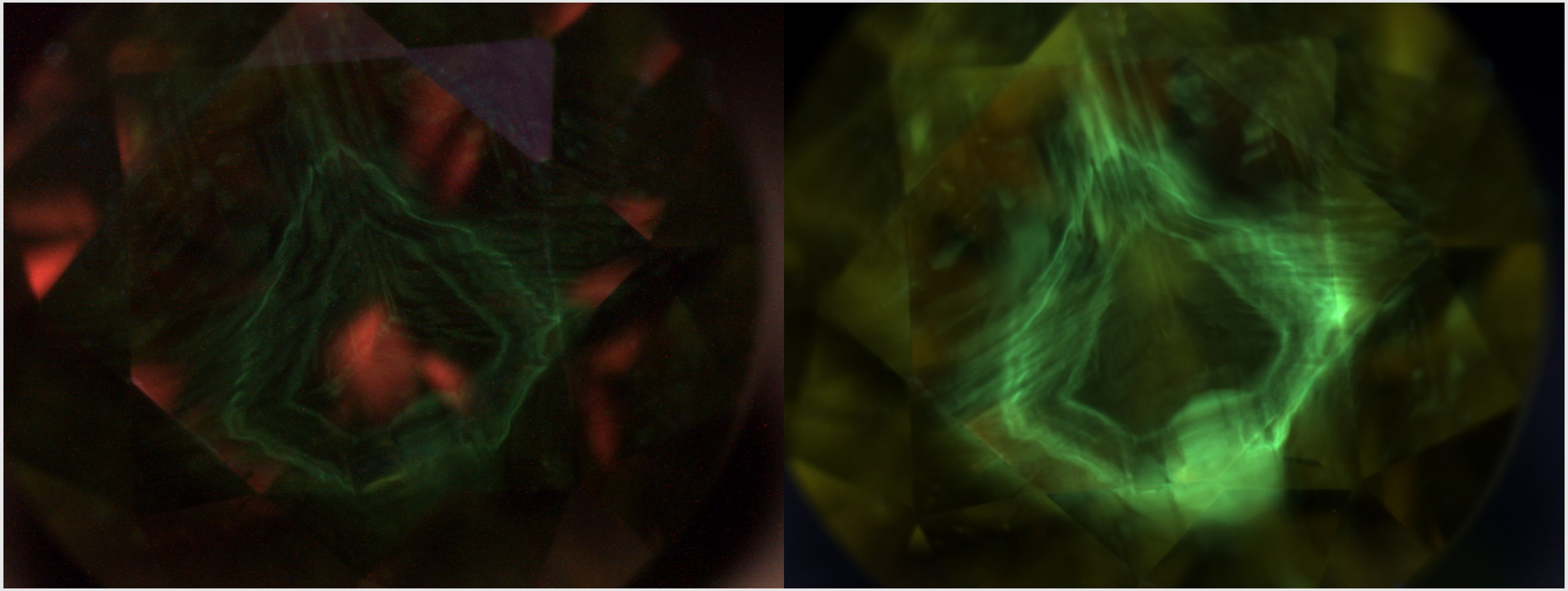


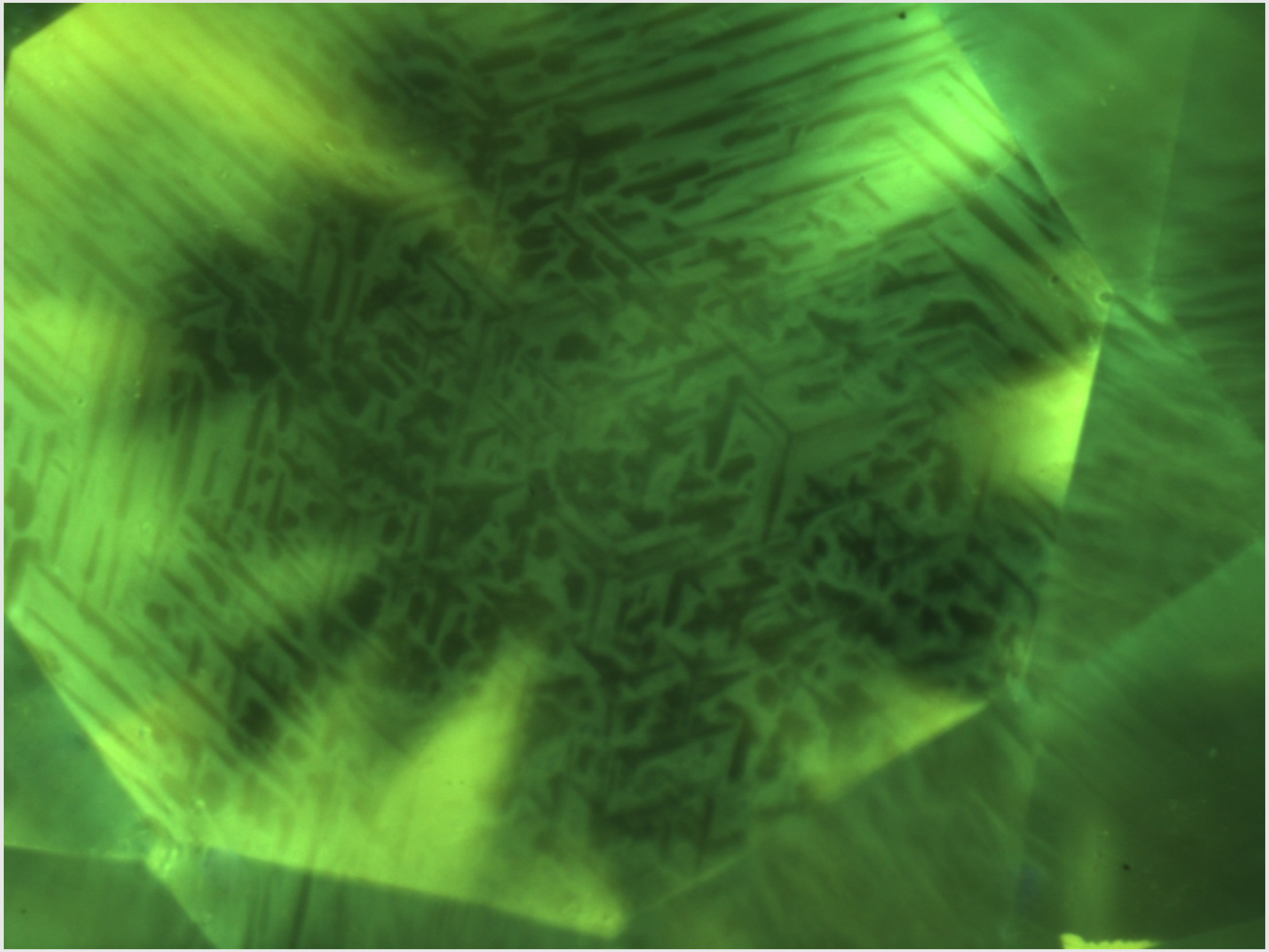


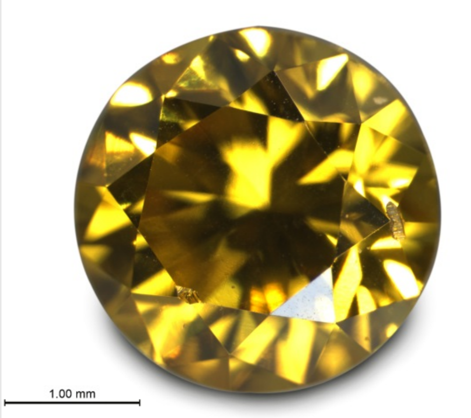


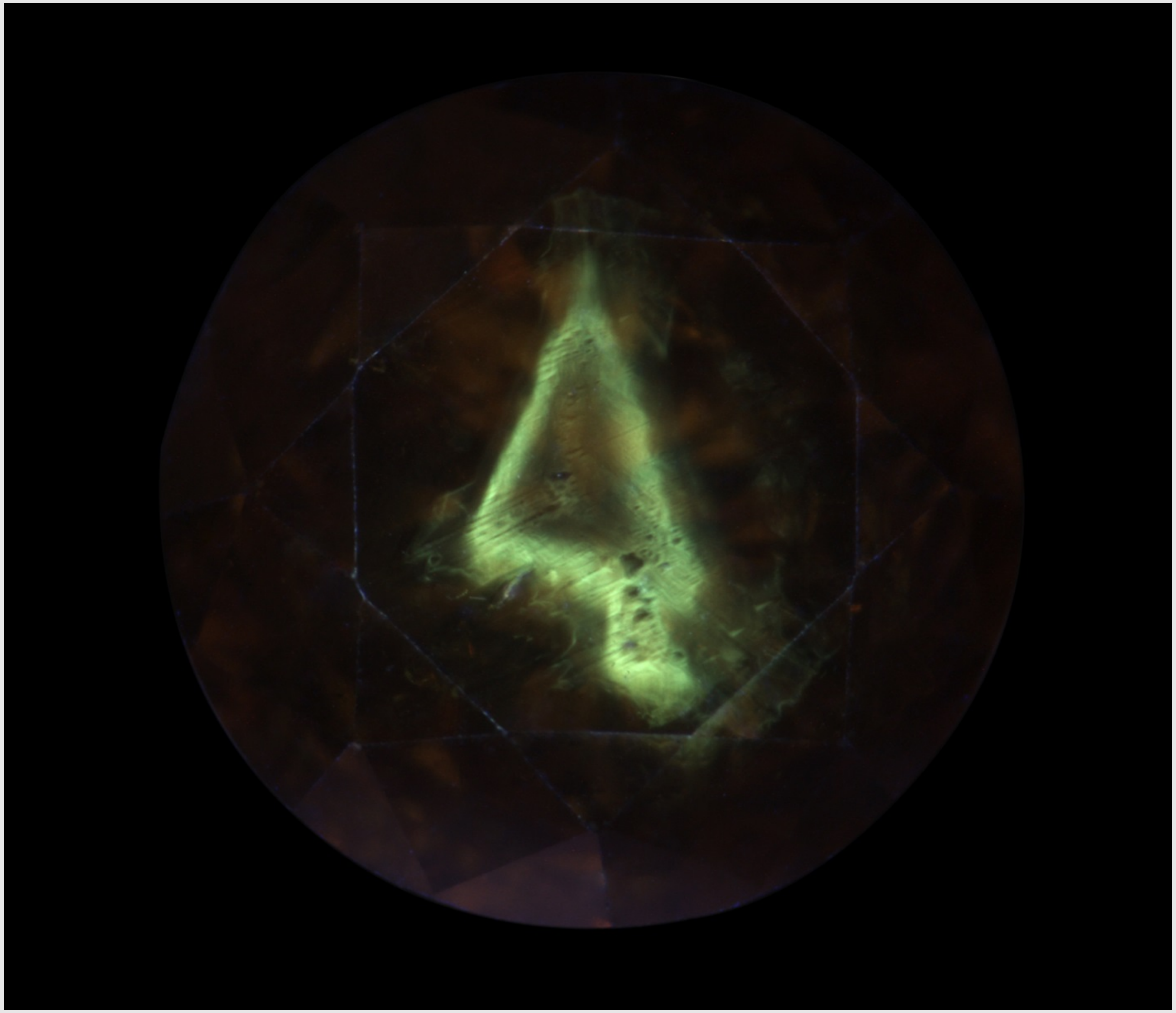




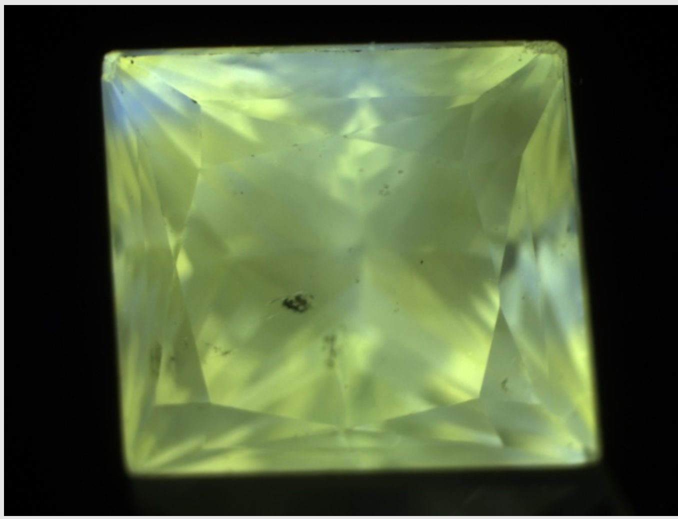


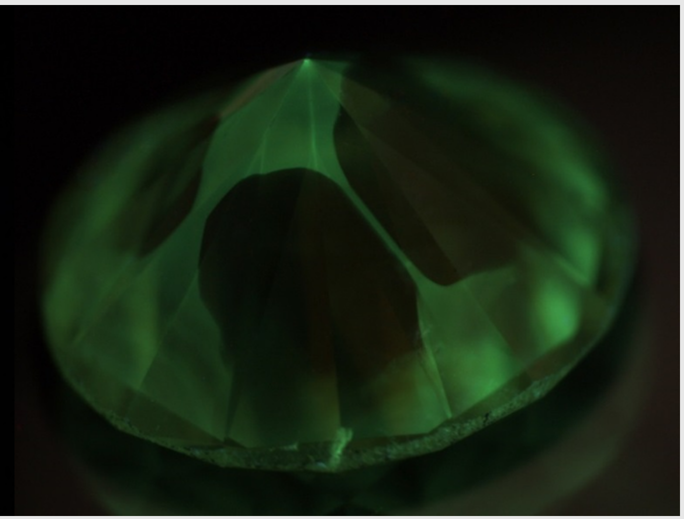


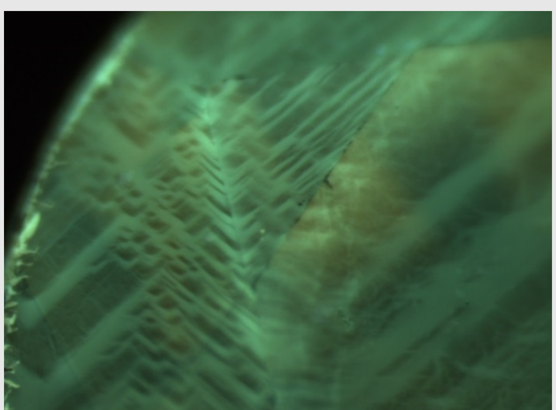

1.00 mm

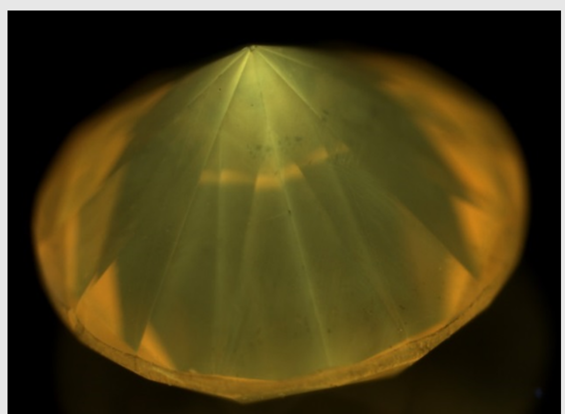


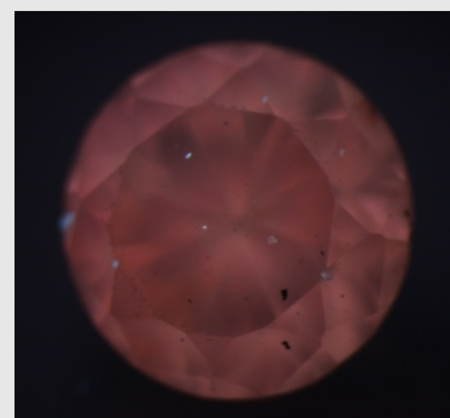
…and many many more…







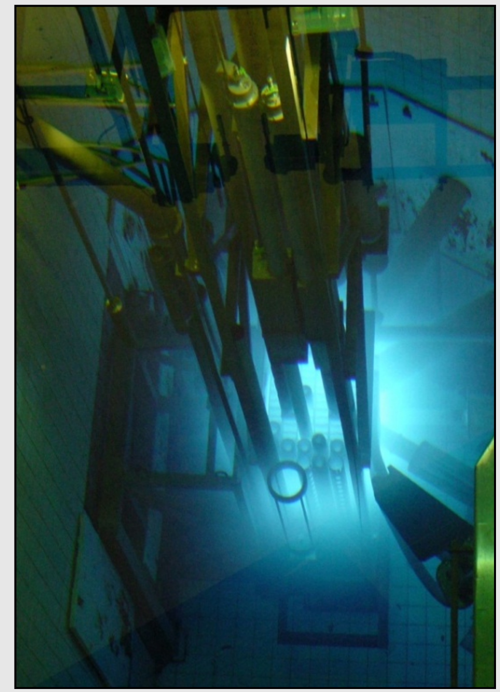




Irradiated diamonds

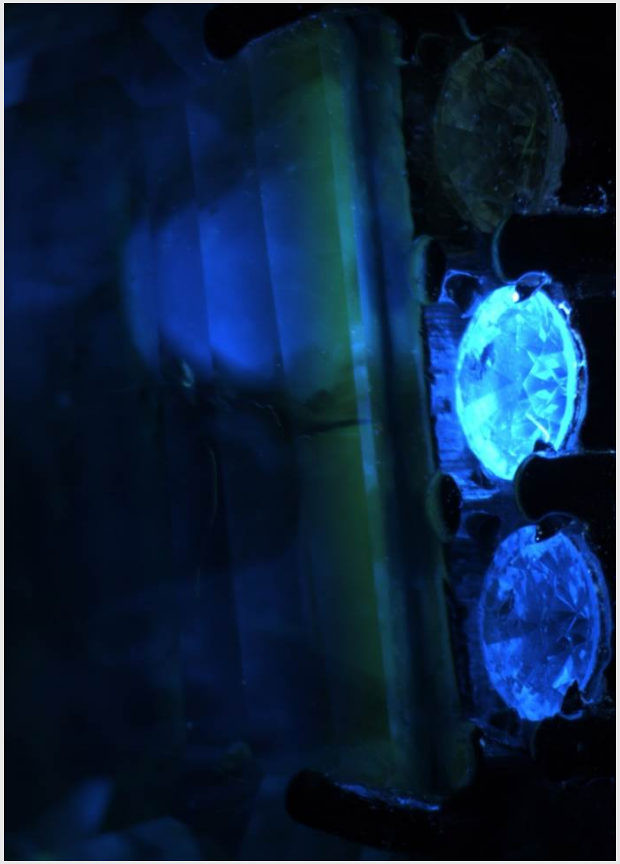
Treatments Methods – Electron + Neutron Irradiation

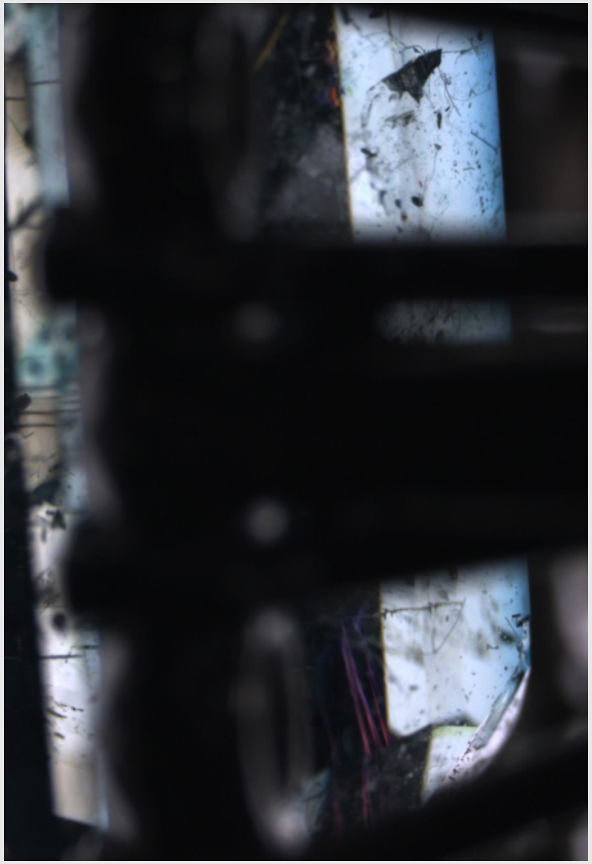
Electron accelerators



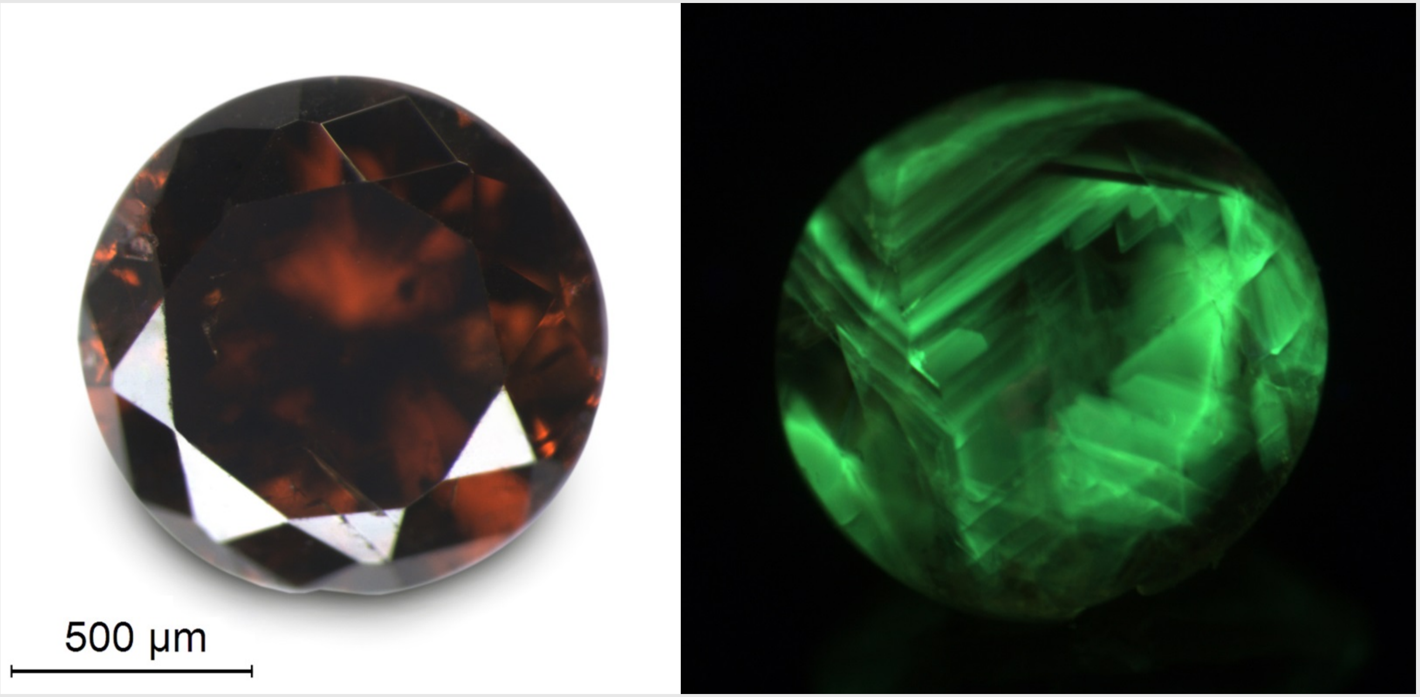
Neutron source exhibiting Tscherenkov radiation (blue light emission) due to fast electrons traversing water

Natural Diamond of Irradiation Treated Colour



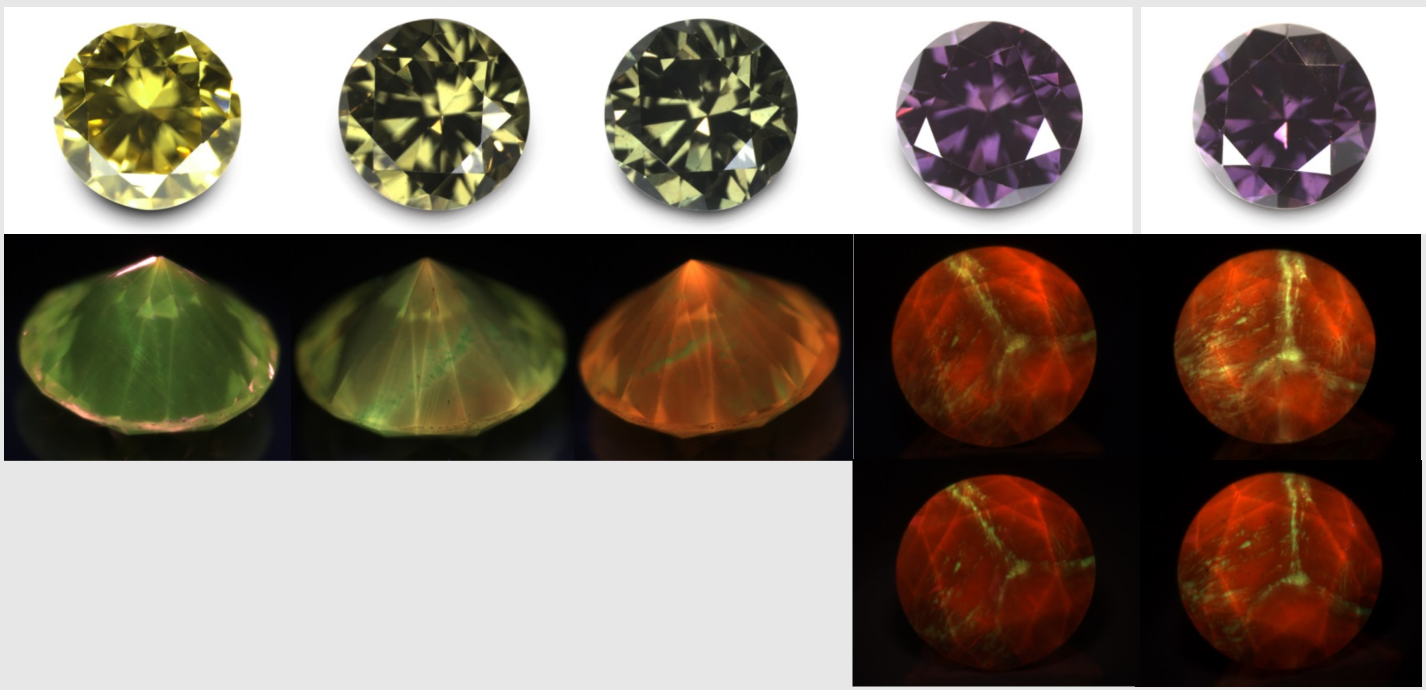


Irradiated / annealed diamonds



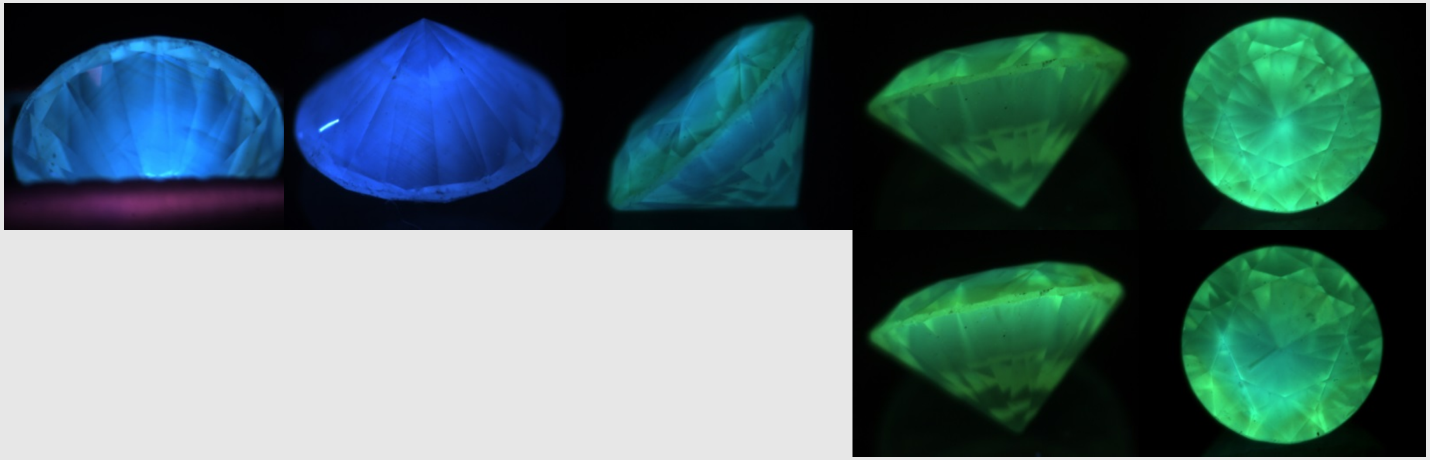
Irradiated / annealed diamonds: type Ib

Untreated Irradiated 600°C 700°C 1310°C



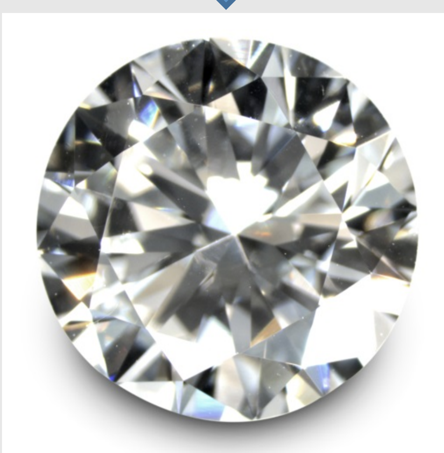
Irradiated / annealed diamonds: type Ia

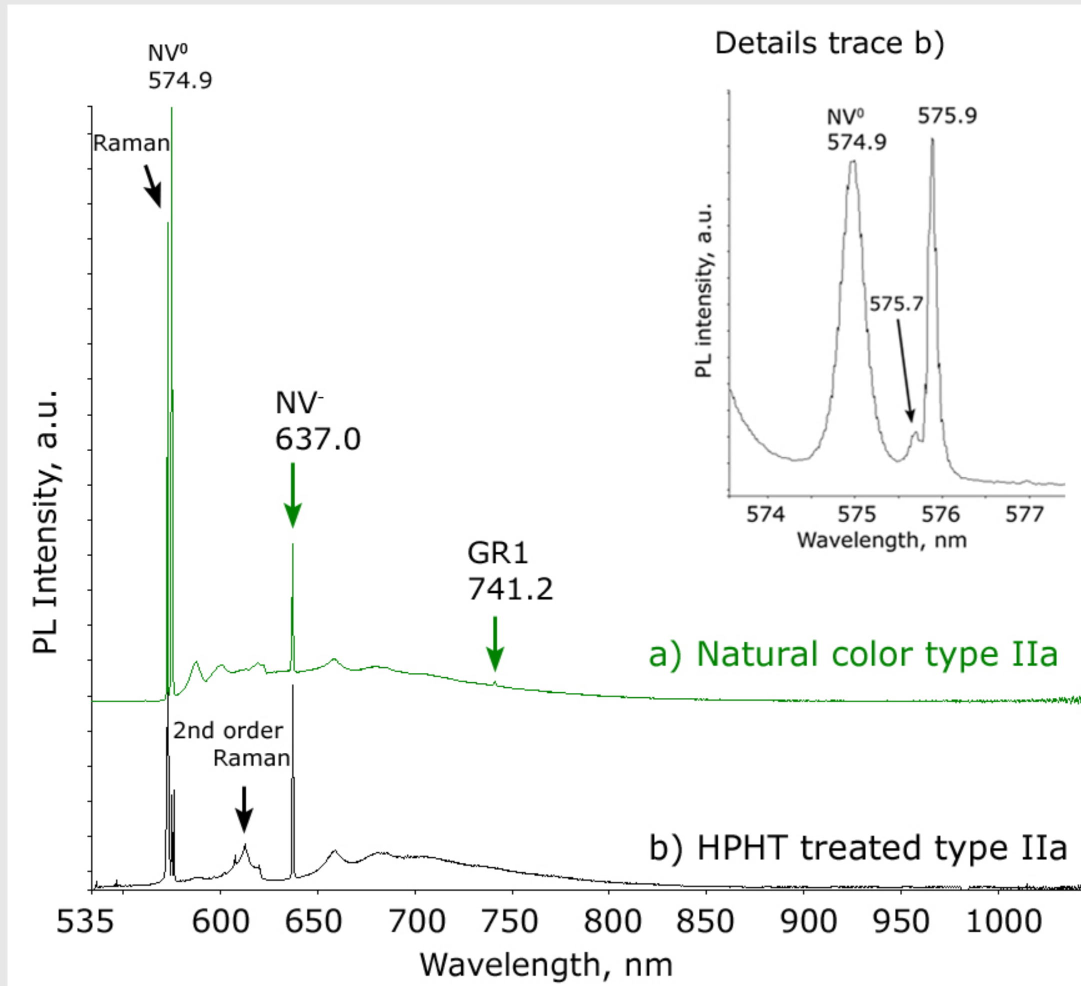
Untreated	Irradiated	600°C	700°C	1310°C



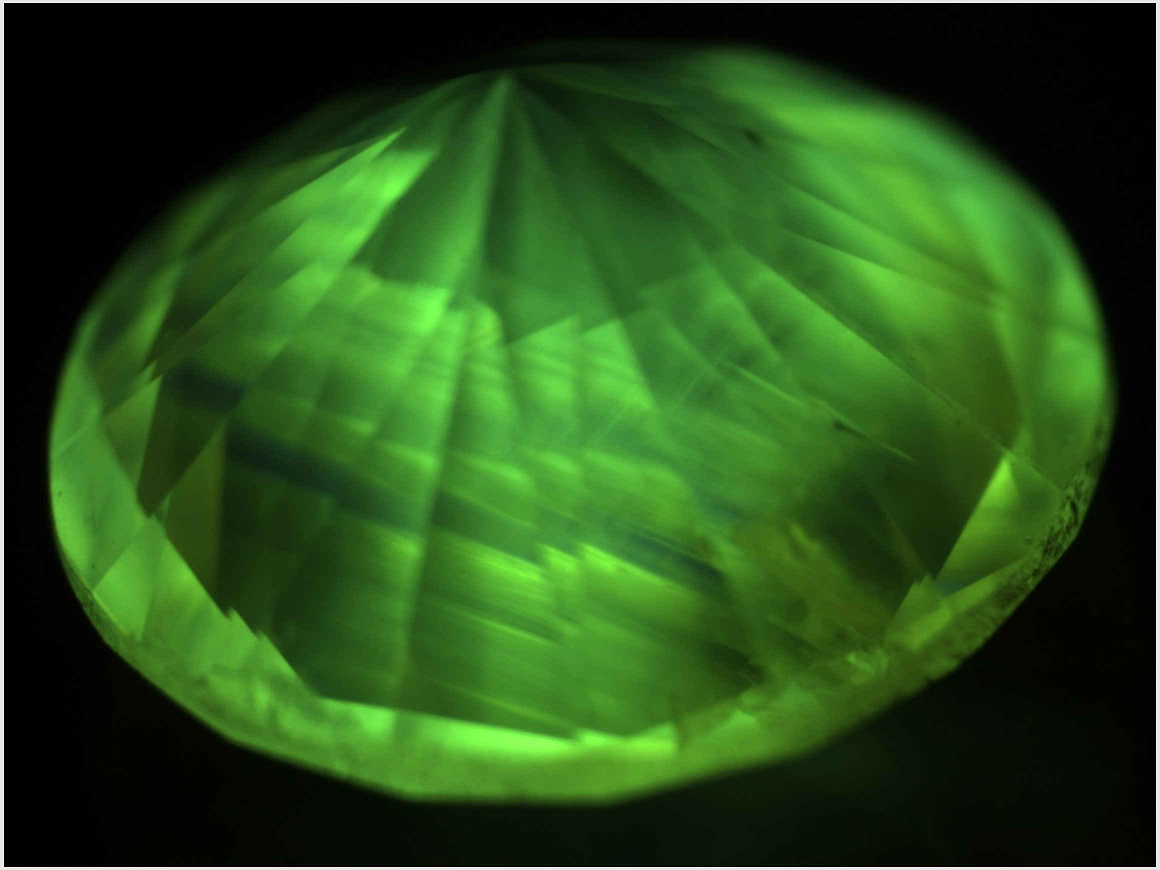
HPHT treated diamonds

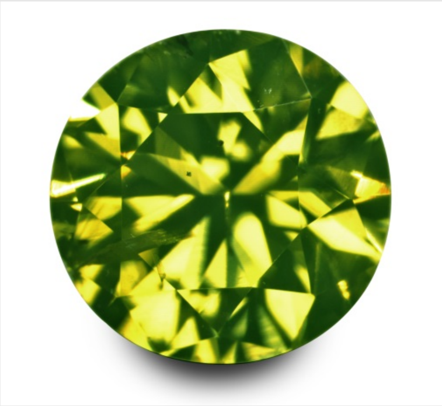
HPHT treated type IIa diamonds



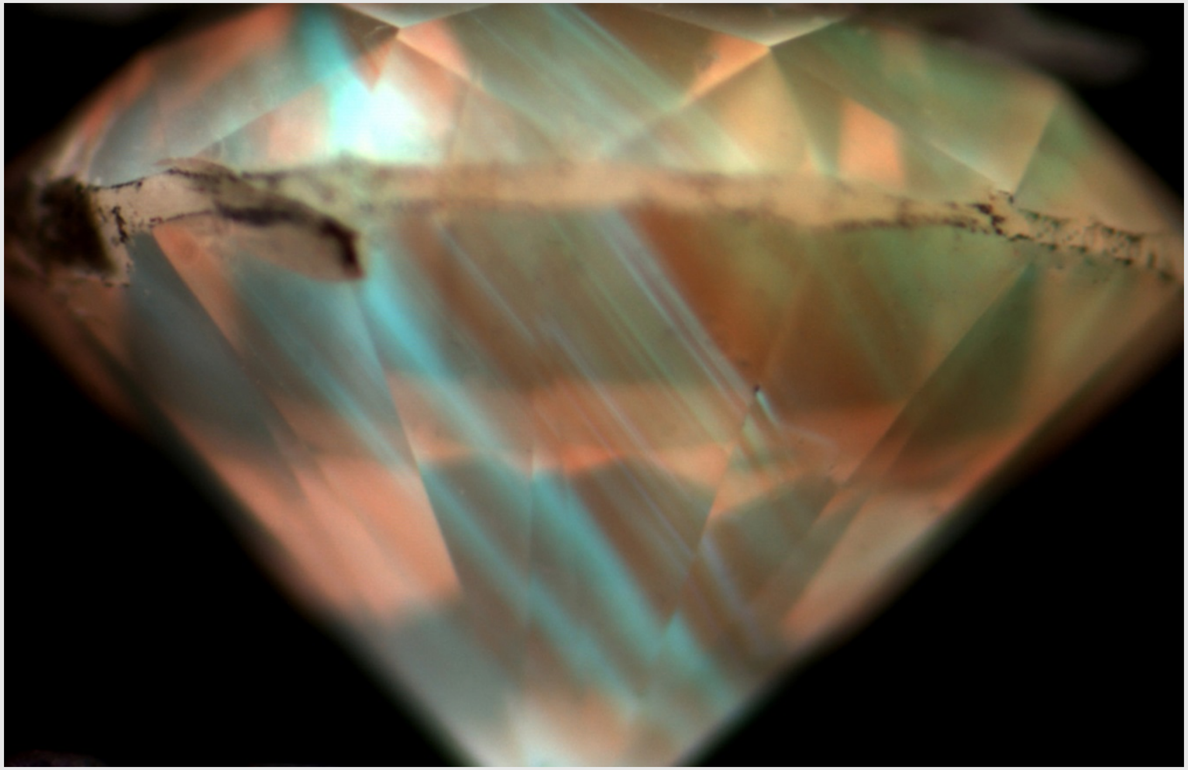


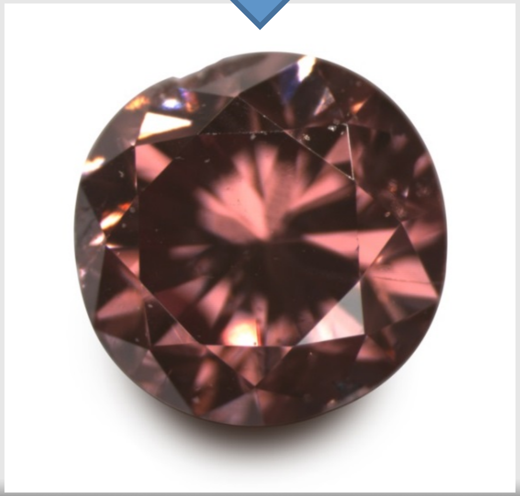
HPHT treated type Ia diamonds





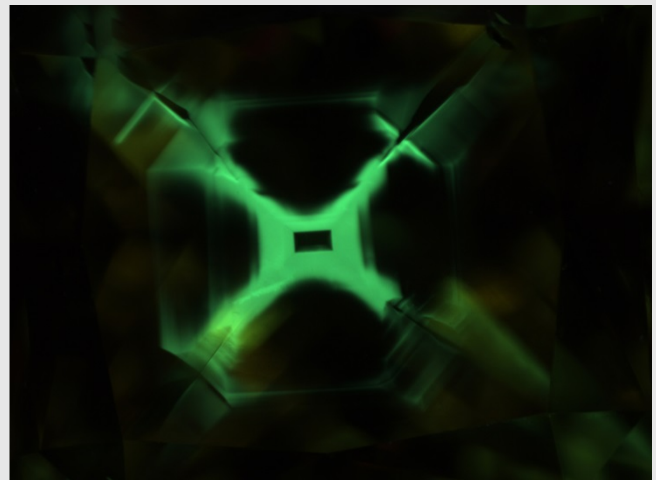
HPHT treated / irradiated / annealed type Ia diamonds

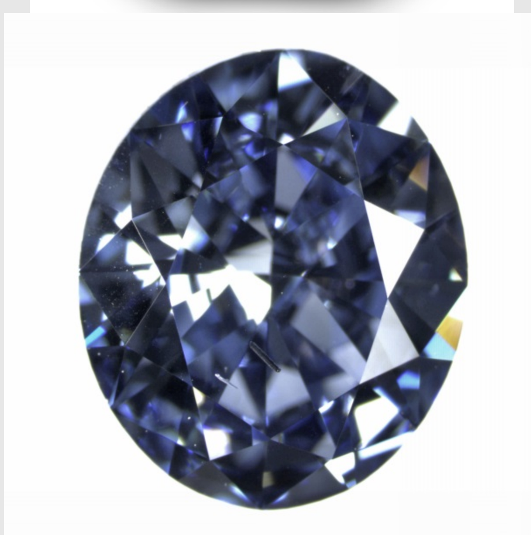




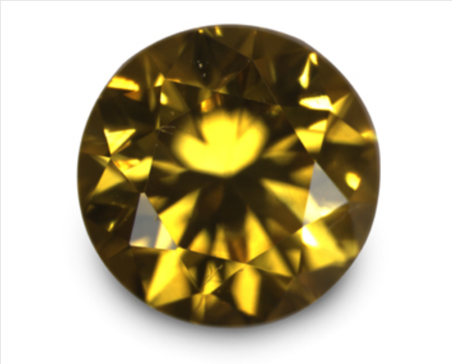
Synthetic diamonds

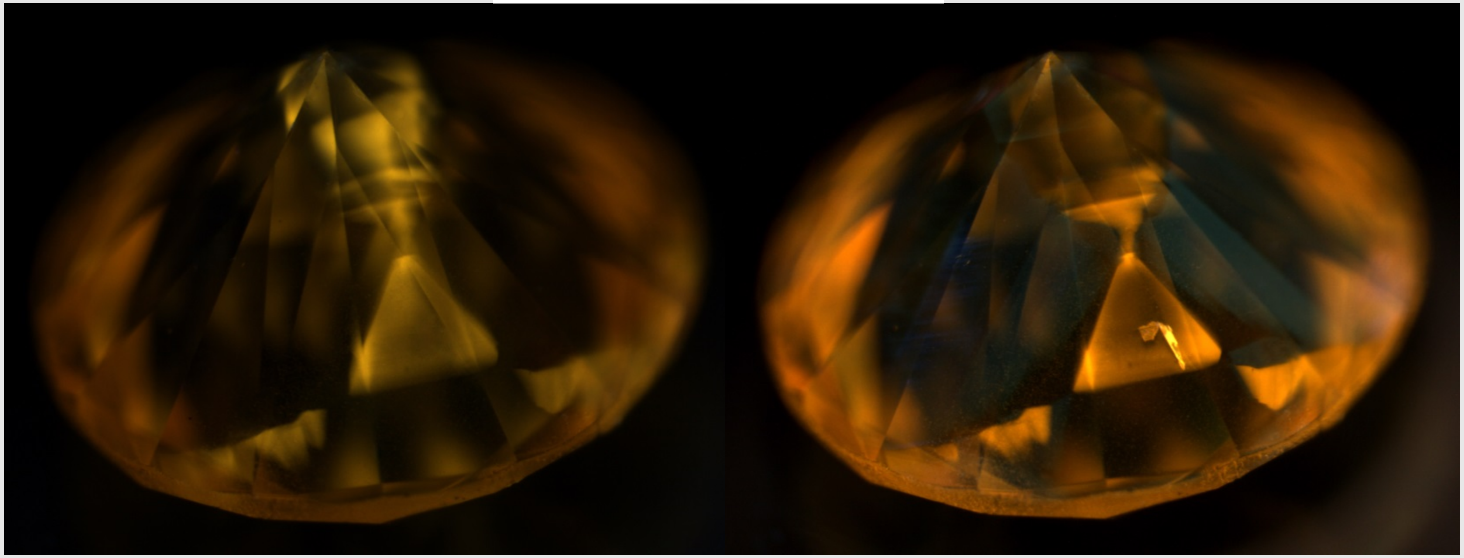
HPHT grown synthetic diamonds

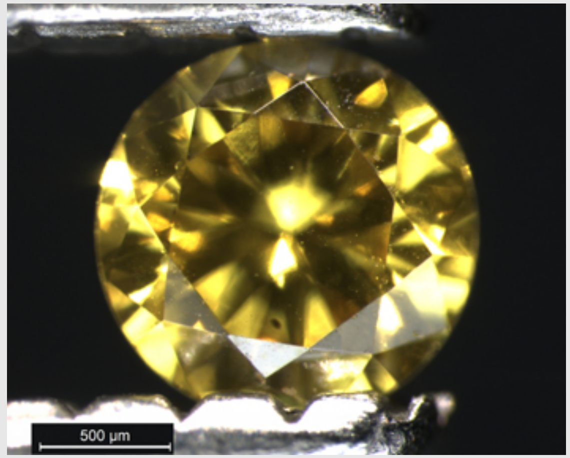


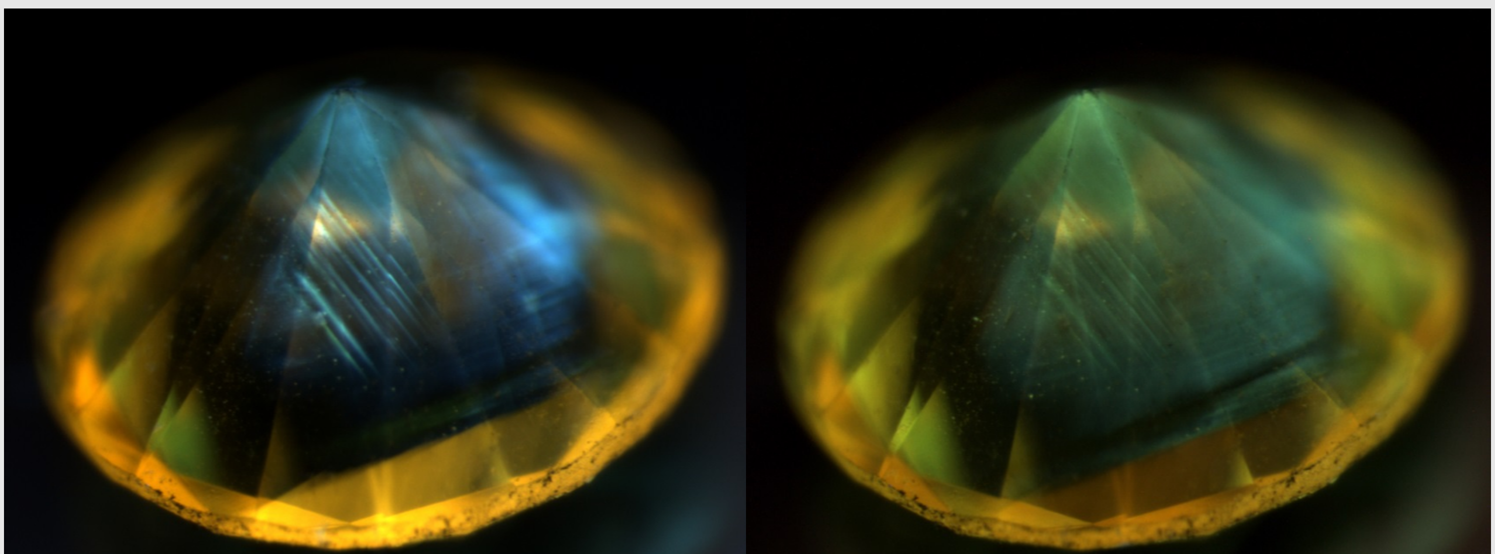


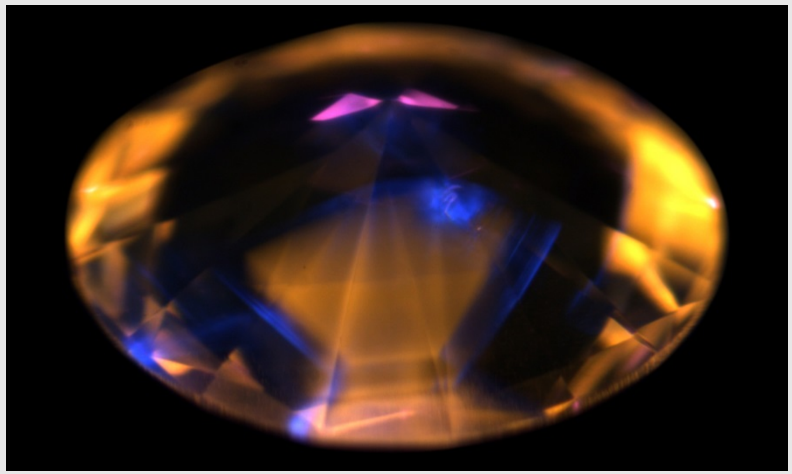
HPHT grown synthetic diamond: Grown from Co-Fe catalysts and multi-treated (HIH)

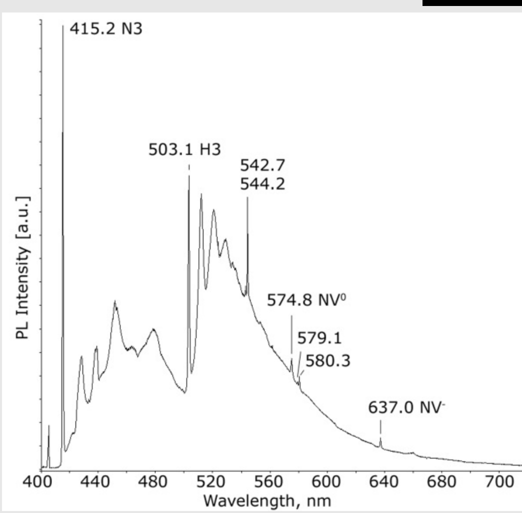


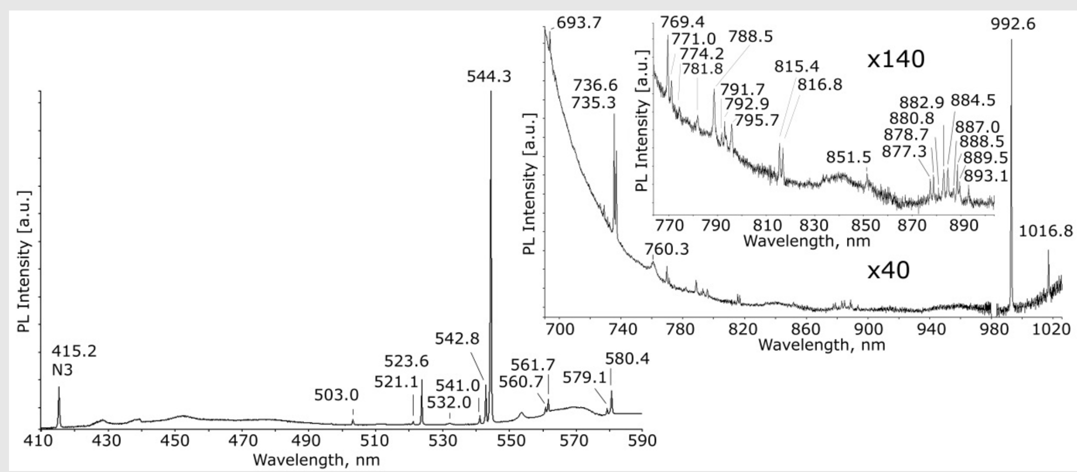



500 µm

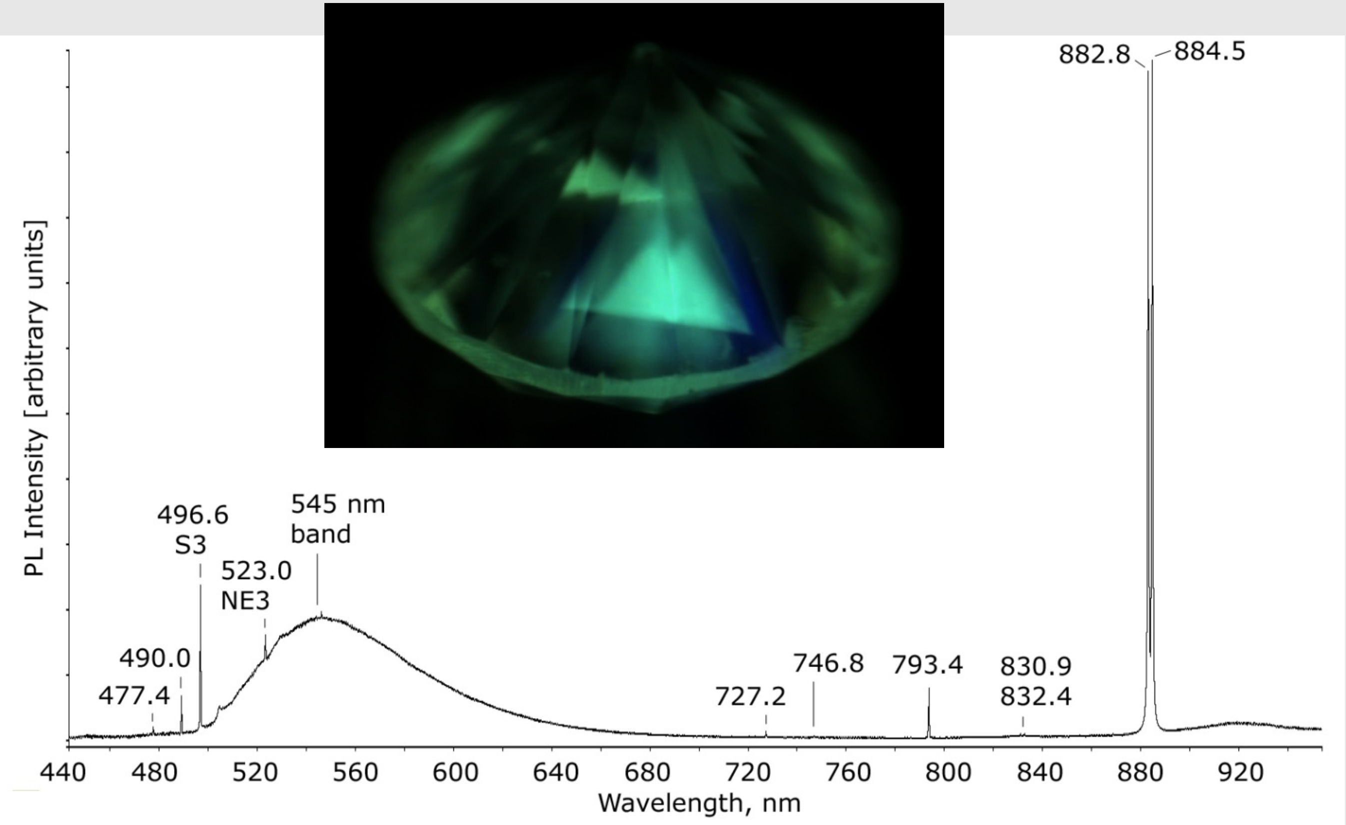




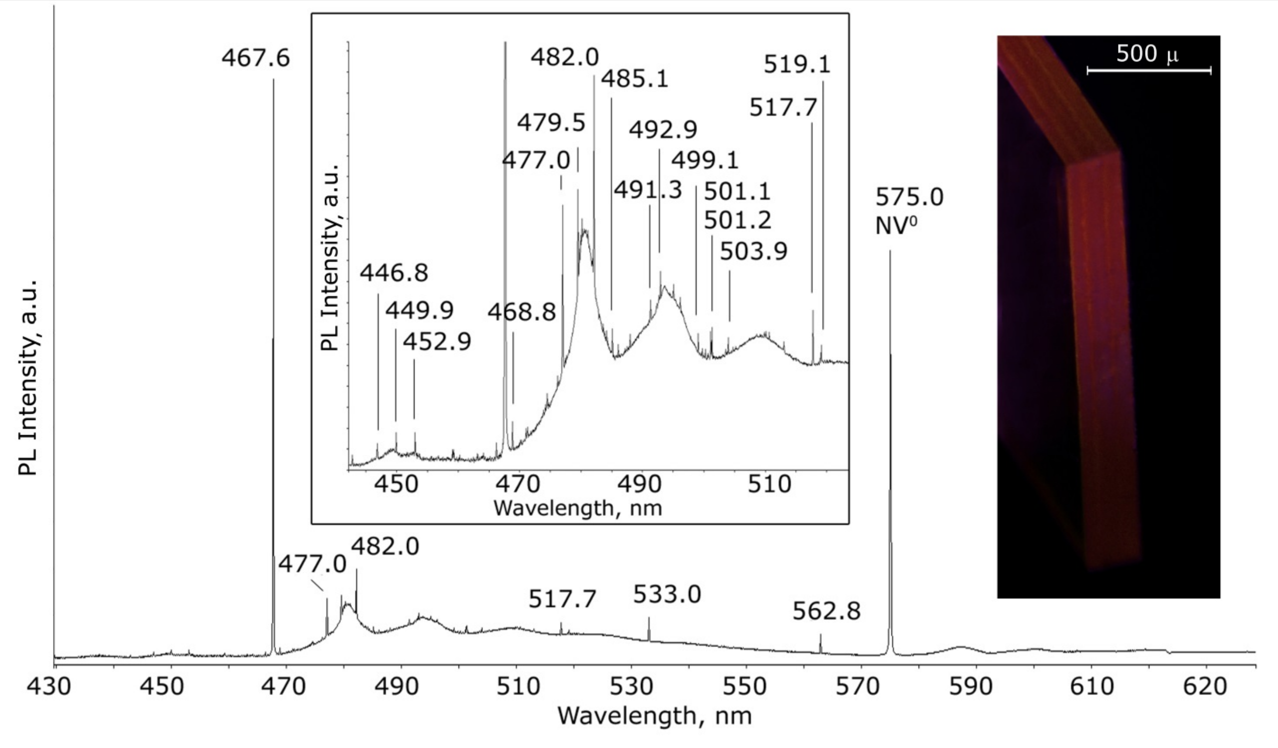

415.2 N3
503.1 H3
542.7
544.2
574.8 NV⁰
579.1
580.3
637.0 NV⁻
PL Intensity [a.u.]
400 440 480 520 560 600 640 680 700
Wavelength, nm


415.2
N3
503.0
521.1
523.6
532.0
541.0
542.8
544.3
560.7
561.7
579.1
580.4
PL Intensity [a.u.]
410 430 450 470 490 510 530 550 570 590
Wavelength, nm
693.7
736.6
735.3
760.3
992.6
1016.8
x40
700 740 780 820 860 900 940 980 1020
769.4
771.0
774.2
781.8
788.5
791.7
792.9
795.7
815.4
816.8
851.5
877.3
878.7
880.8
882.9
884.5
887.0
888.5
889.5
893.1
x140
770 790 810 830 850 870 890

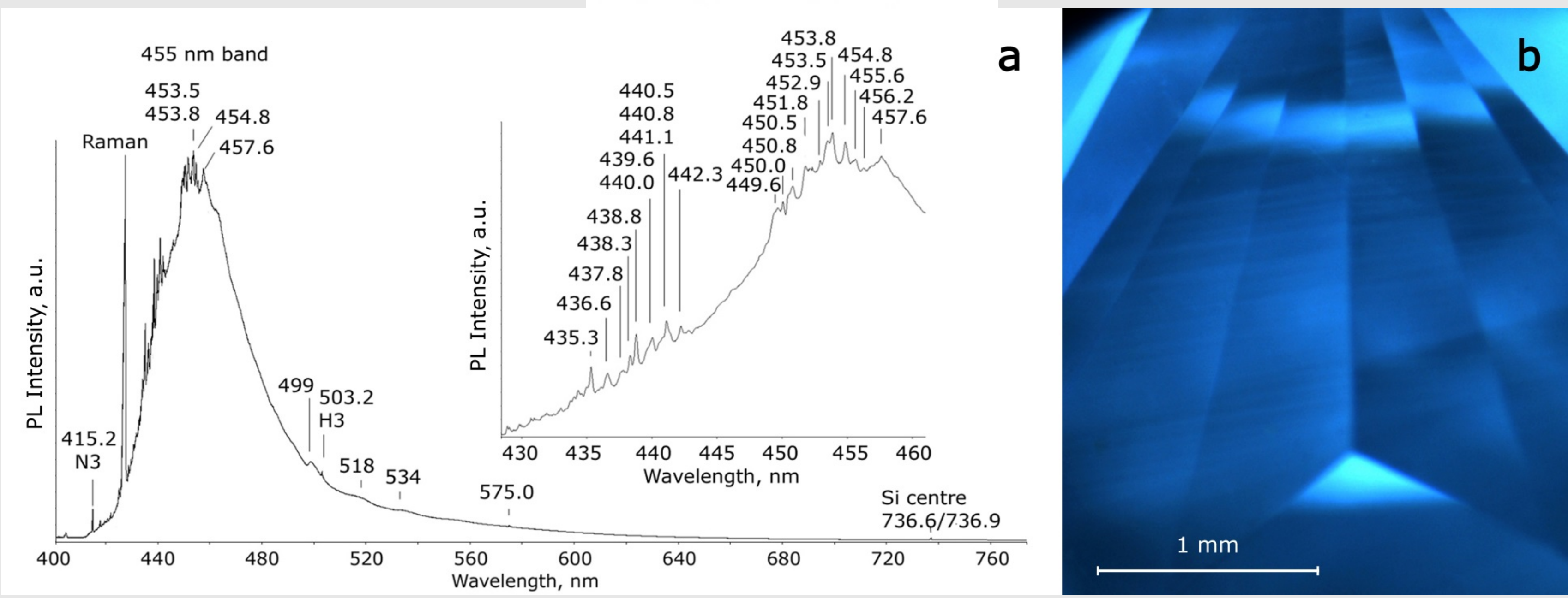
HPHT grown multi treated synthetic diamond (HIH): Ni-Fe catalyst



CVD grown synthetic diamond



CVD grown synthetic diamond, HPHT treated



Summary and conclusions

→ Fluorescence analysis includes some of the most important techniques for gem testing.

→ Fluorescence imaging can help identifying treatments, imitations and synthetics.

→ Fluorescence imaging is of great importance in melee diamond testing.

→ Photoluminescence spectroscopy helps characterizing defects, especially in diamond, which are undetectable by any other method.


Thank you