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Investigation of crystallites in CVD diamond films and their impact on stress distribution

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HAL Authorization

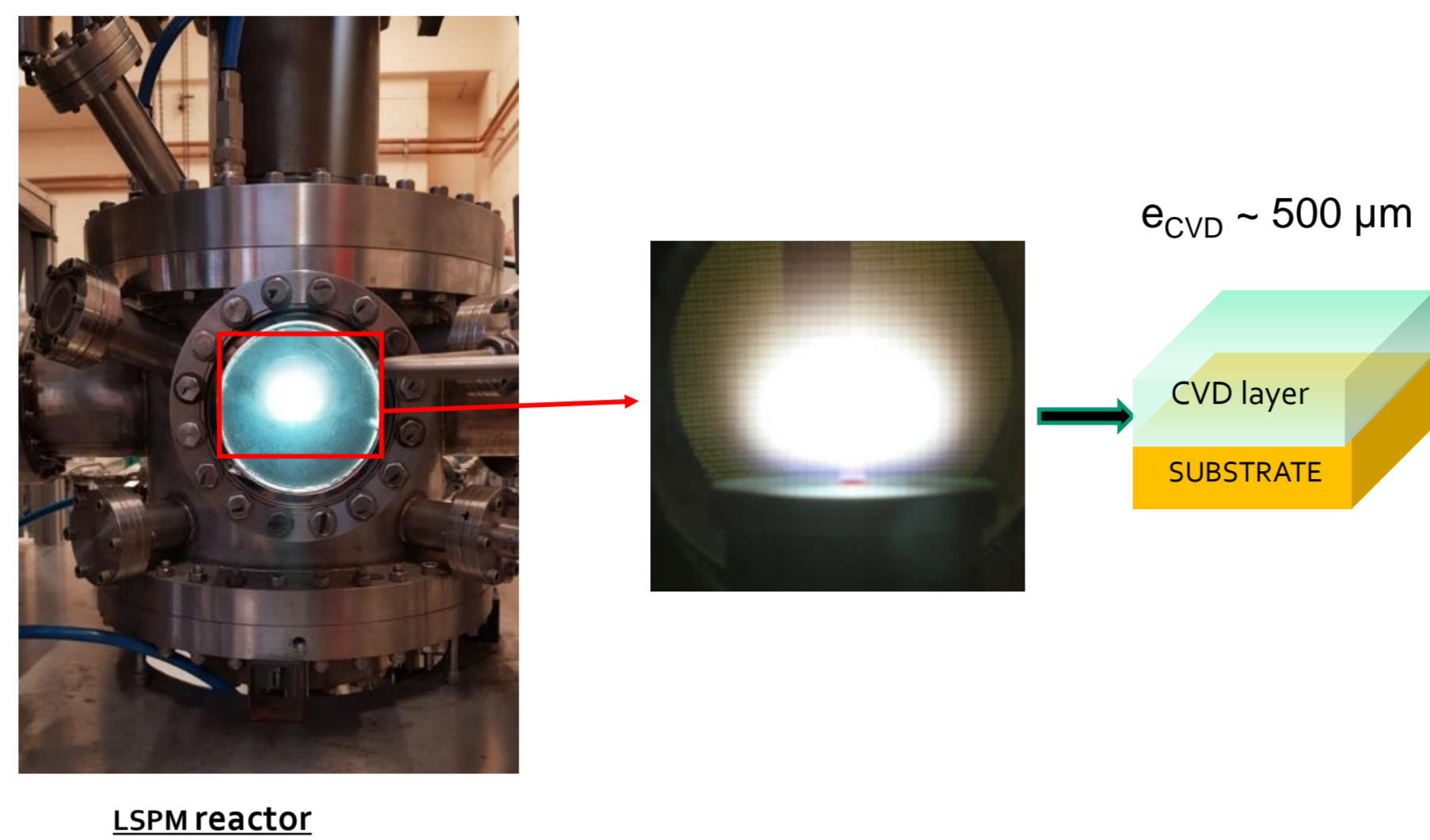
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Introduction

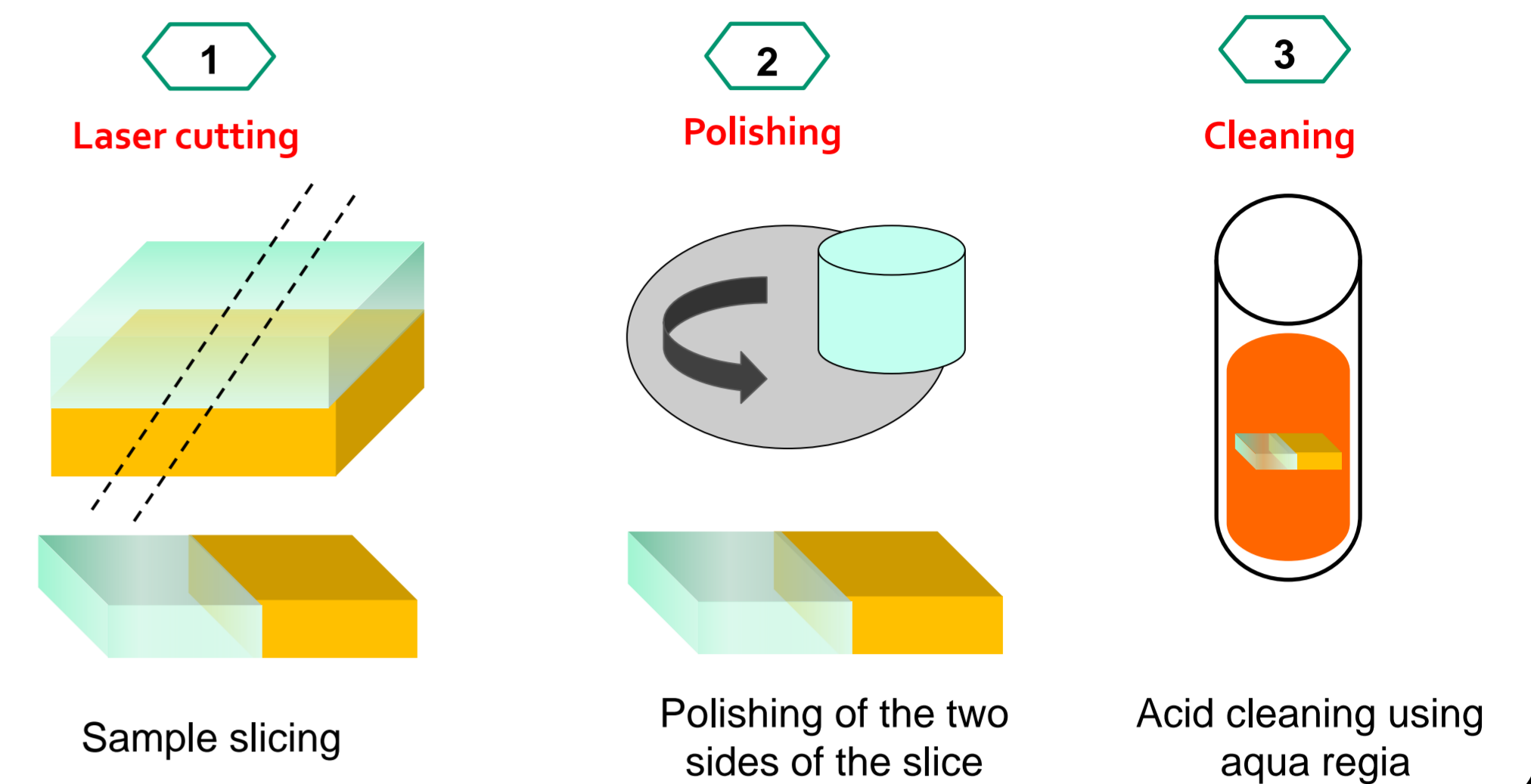
Diamond's exceptional physical and chemical properties make it ideal for applications in electronics, quantum technologies, optics, mechanics, thermal management, and biomedicine. However, achieving high-quality CVD diamond films is challenging due to the formation of crystallites during growth. These microstructures disrupt layer uniformity, alter material properties, and induce localized strain, increasing internal stress. This stress can degrade the film's structural integrity over time, posing significant concerns for applications requiring high precision, such as quantum technologies. This study focuses on characterizing crystallite morphology and related stress fields to improve CVD diamond quality.

Sample preparation

1) Growth



2) Cross section



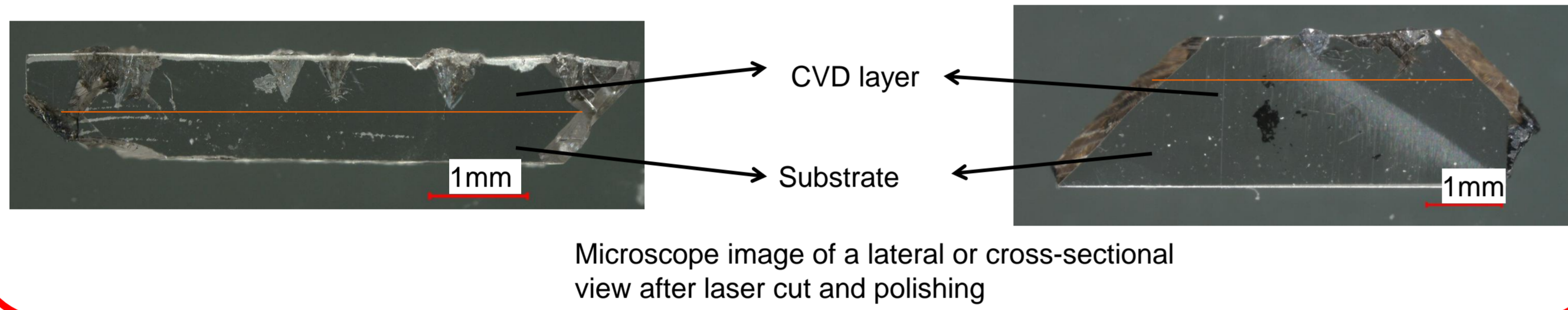
Stress-Strain Observation

Samples slices

Nitrogen doping

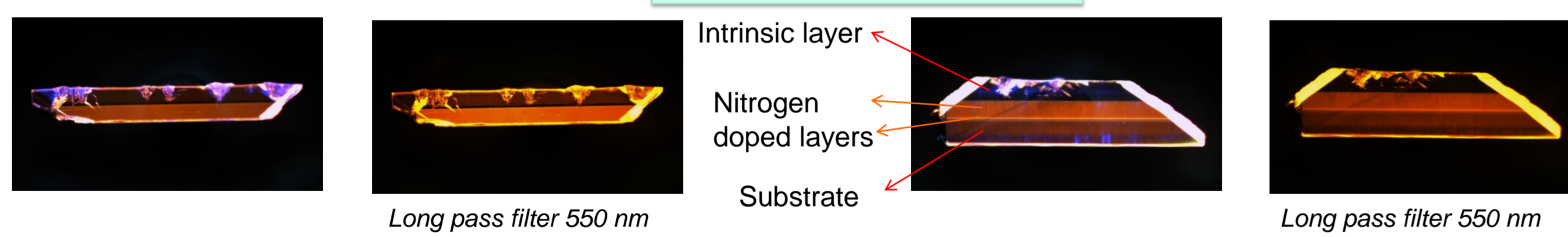
Without Doping

Optical image



Microscope image of a lateral or cross-sectional view after laser cut and polishing

Diamond View

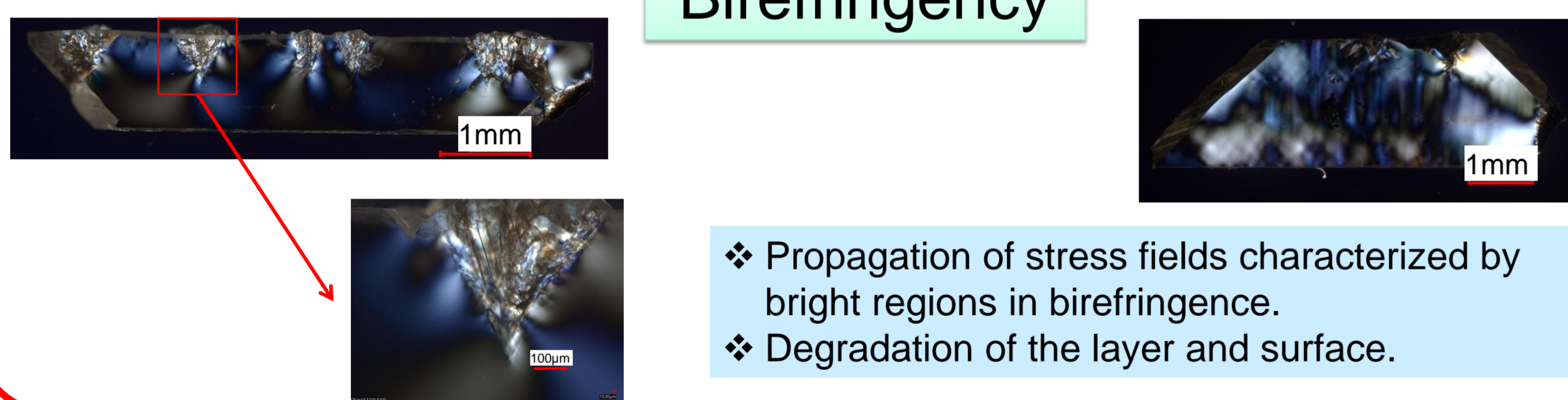


There's more nitrogen in the crystallites than in the layer -> The orange color in the crystallites is brighter than in the layers.

No nitrogen observed in the intrinsic layer, but the crystallites contain nitrogen.

Both show the presence of strain localized at the crystallites, highlighted by blue luminescence.

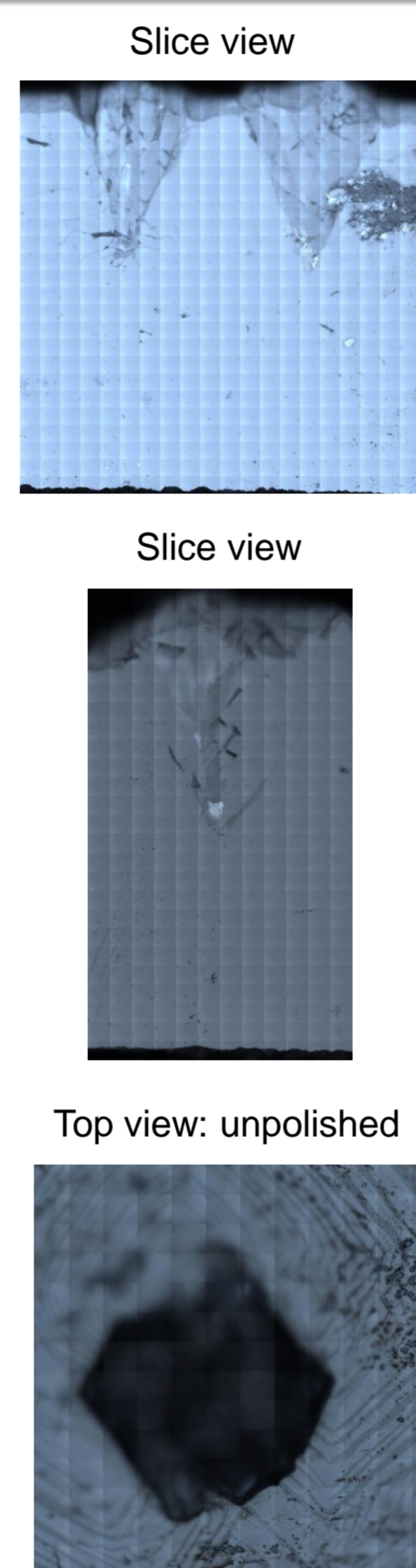
Birefringency



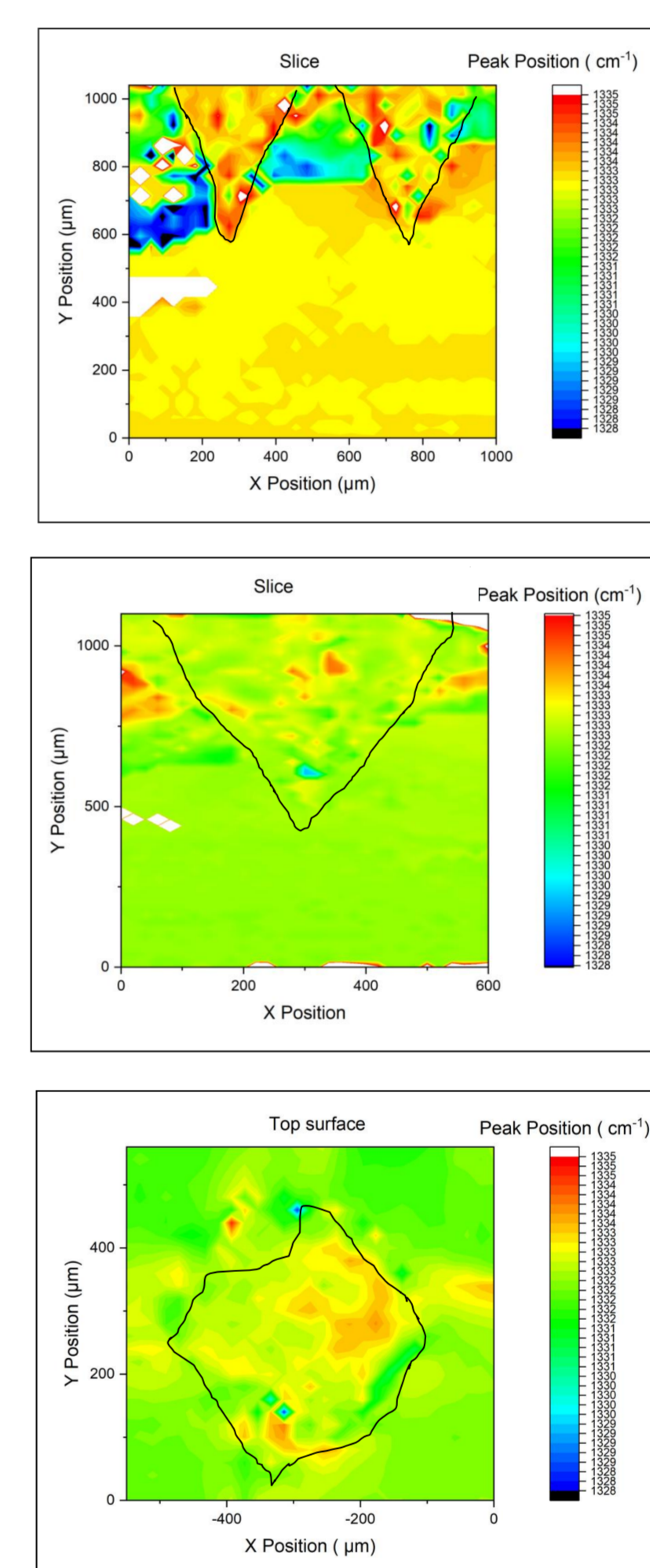
- ❖ Propagation of stress fields characterized by bright regions in birefringency.
- ❖ Degradation of the layer and surface.

Raman Spectroscopy

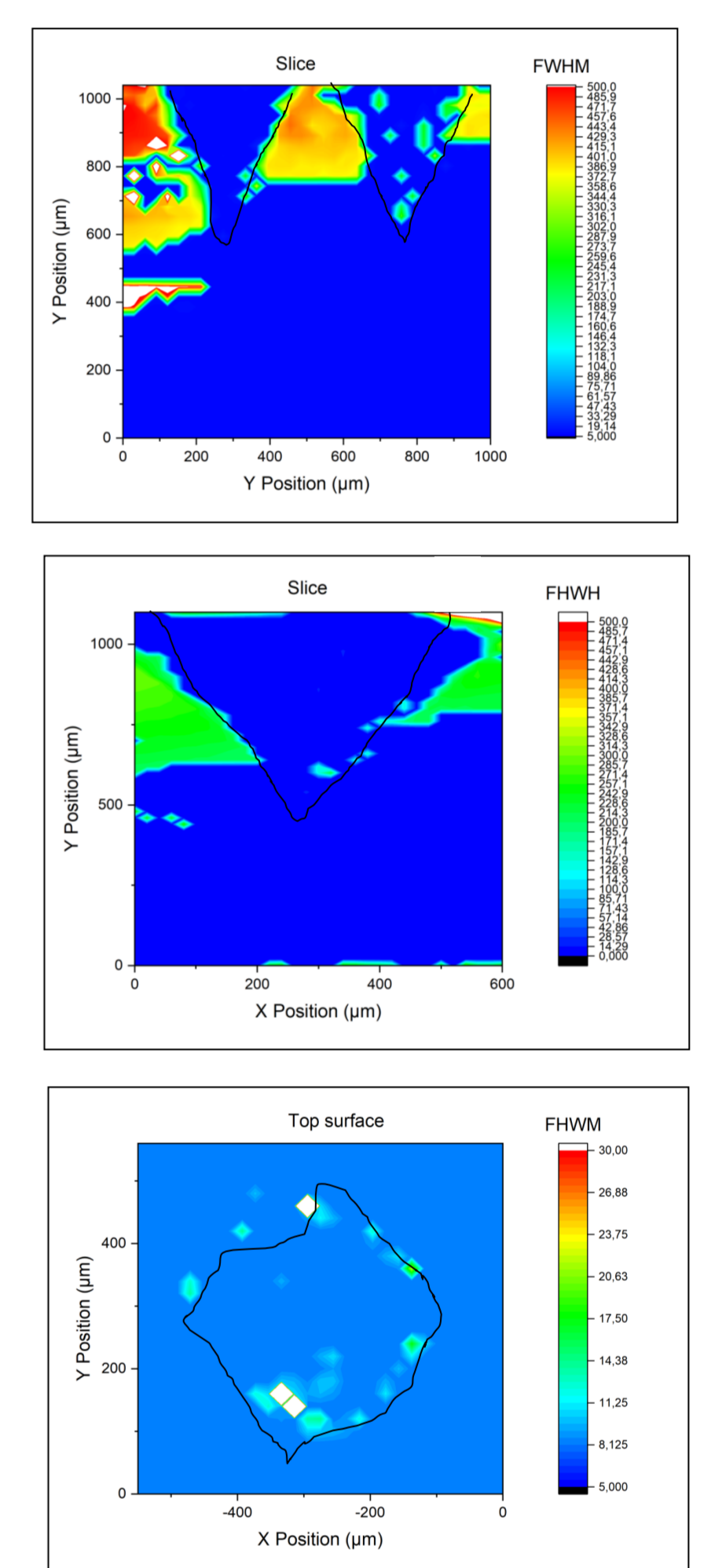
Crystallites Optical images



Peak Shift



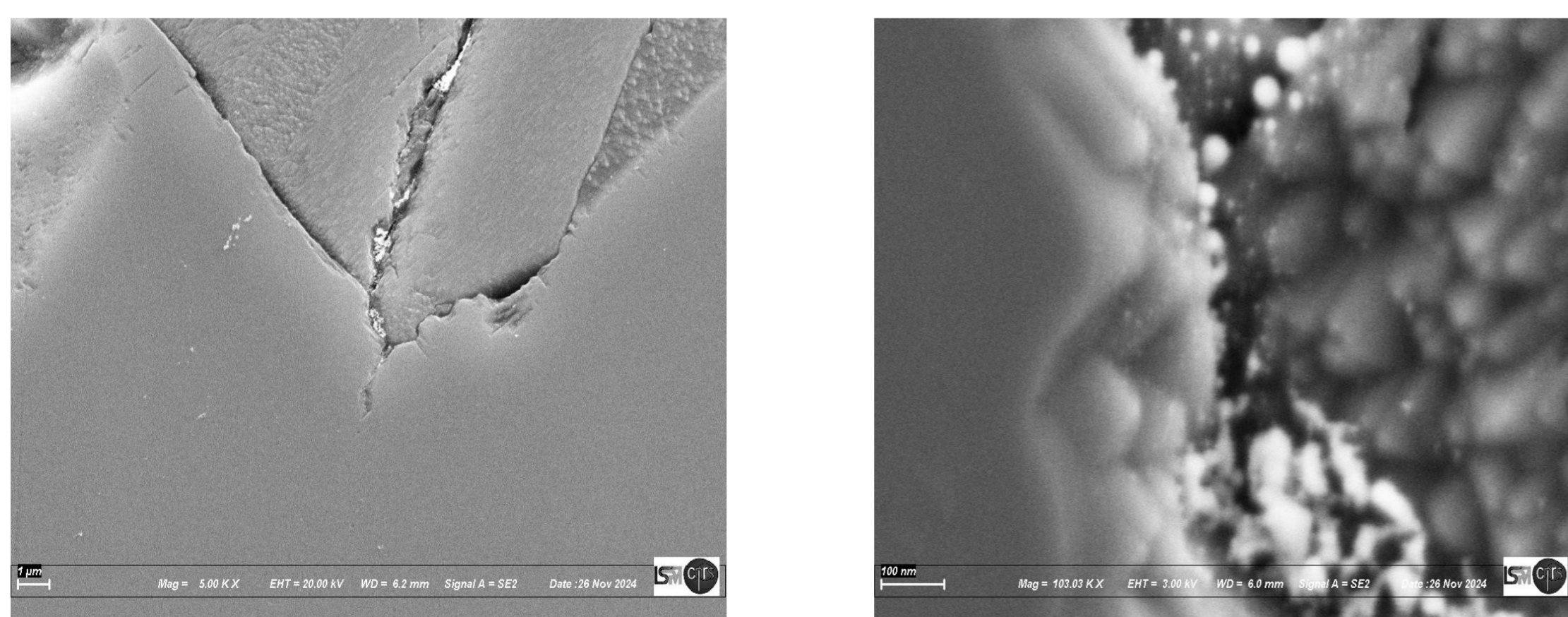
FWHM



- ❖ **Crystallites:** Well-defined crystallites with varying sizes influence the local structure and properties of the CVD diamond film.
- ❖ **Peak Shift:** Raman maps reveal high compressive stress ($\Delta P > 0$) and tensile ($\Delta P < 0$) concentrated into and around crystallites.
- ❖ **FWHM:** Blue regions (low FWHM) within crystallites better crystallinity compared to surrounding areas.

Surface morphology

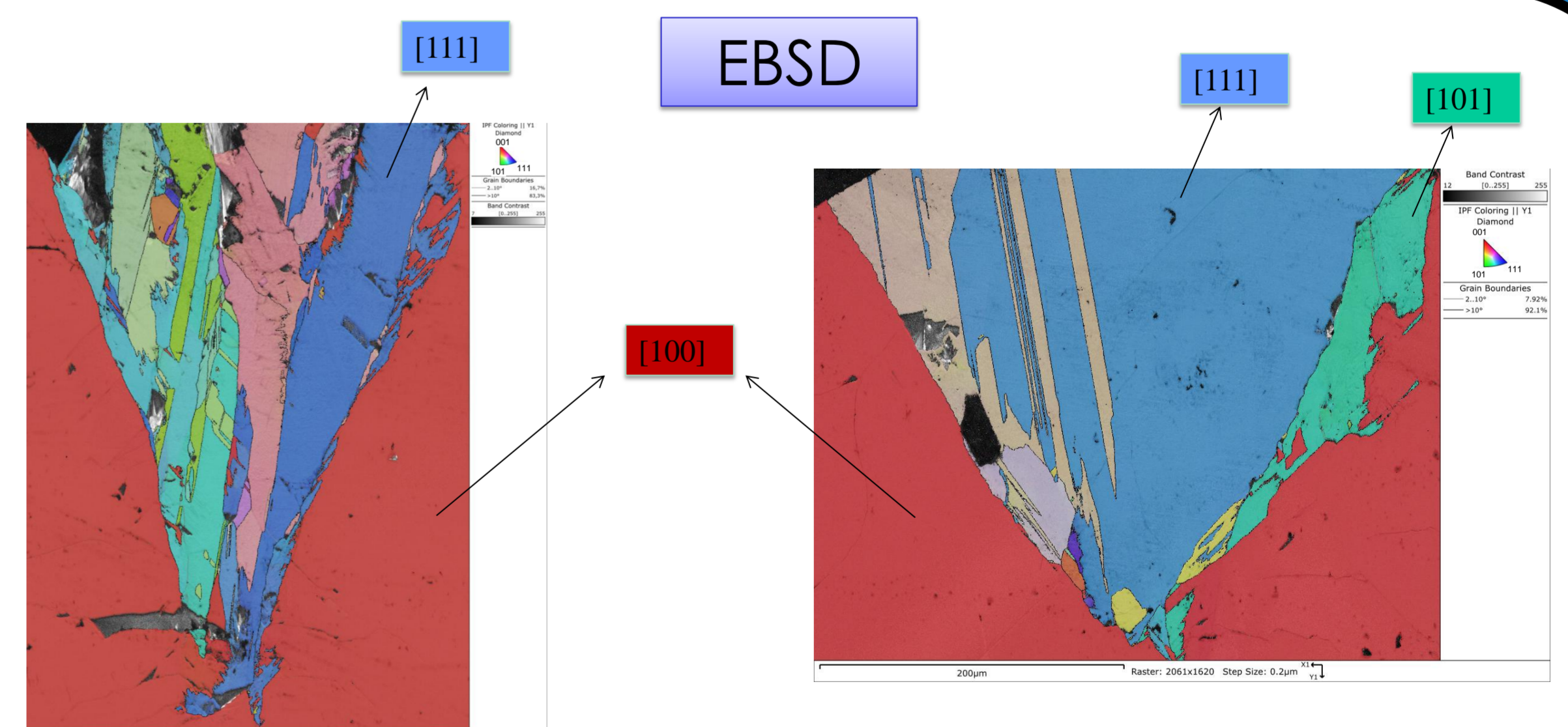
SEM



- ❖ Various possible crystallographic orientations.
- ❖ Cracks probably caused by stress.
- ❖ Presence of non-diamond inclusions.

Crystalline structure

EBSD



- ❖ The crystallites are well-defined and show a variety of orientations, indicating polycrystalline growth.
- ❖ The red regions $\langle 100 \rangle$, show a dominant orientation different from that of the colored crystallites in the center.

Conclusions and perspectives

- ❑ The incorporation of nitrogen into crystallites is favored by the [111] direction present in the latter.
- ❑ Crystallites can be caused by dislocations or impurities.
- ❑ Directions [101] and [111] may suggest twinning

- ❑ Identify the origin of crystallite and why they appears.
- ❑ In-depth study of the impact of crystallites on diamond properties.
- ❑ For a better understanding, characterization folds are planned