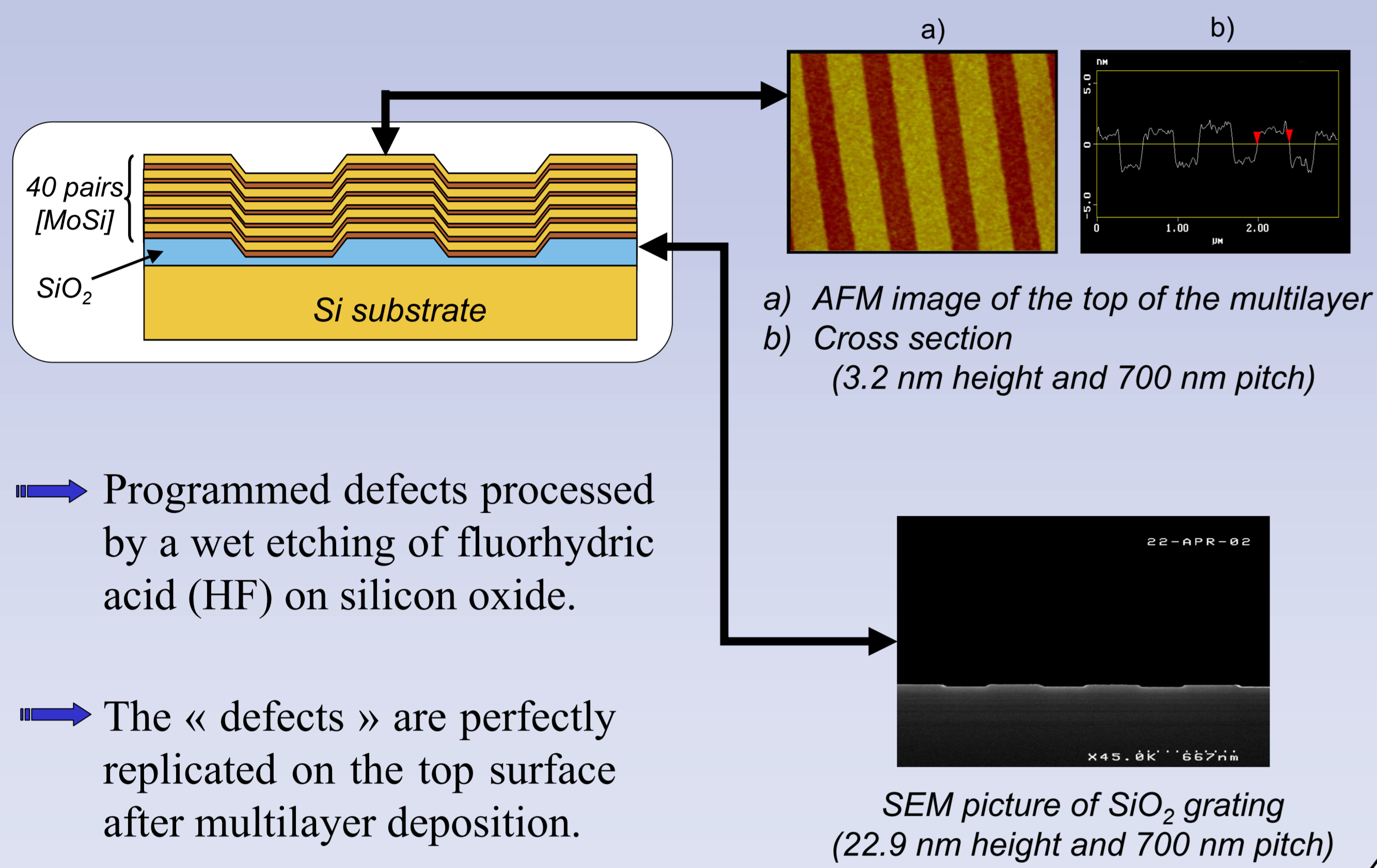


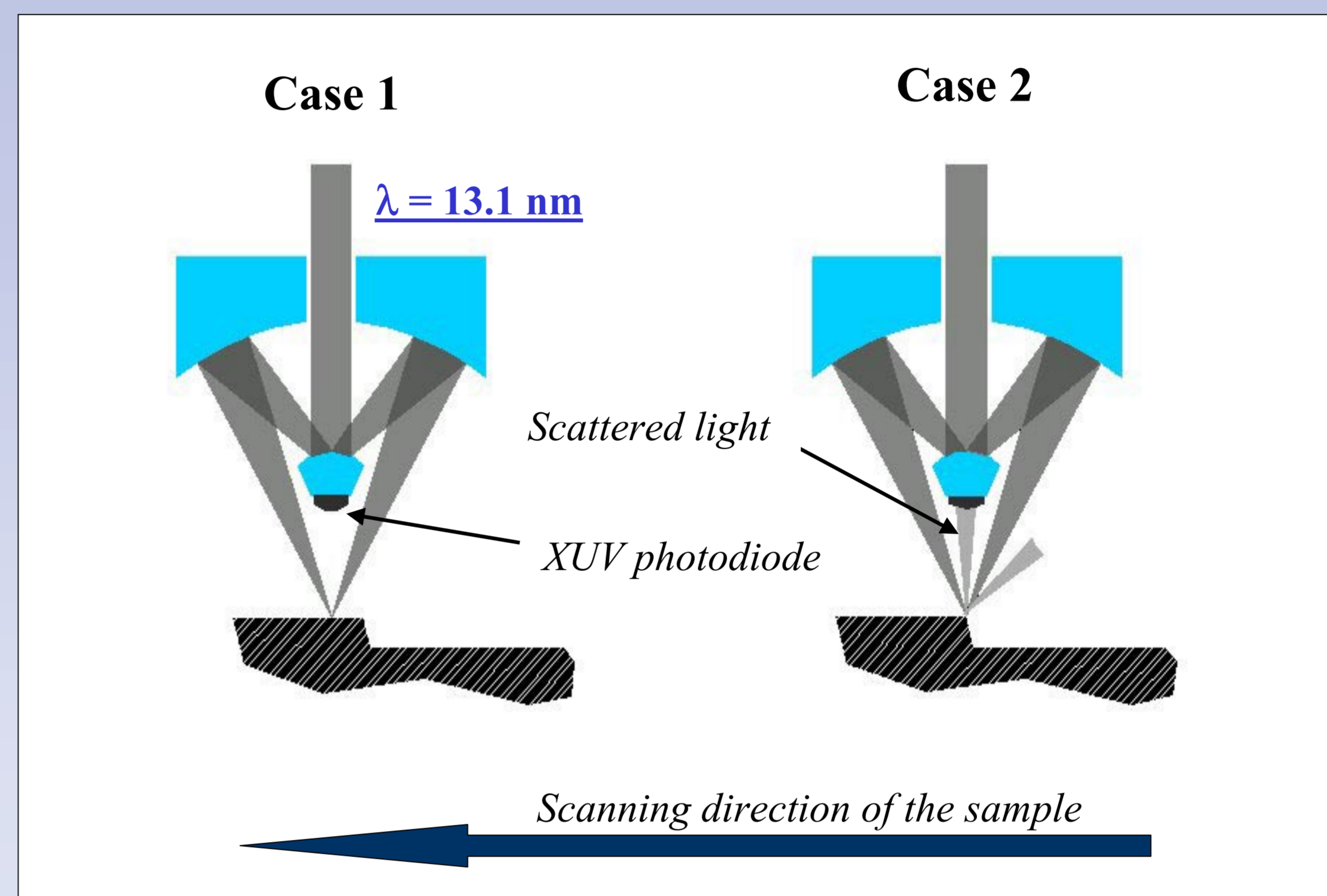
Abstract

In order to assess the capability of at wavelength inspection to capture multilayer defects, we have implemented a dark-field detection mode on the scanning Schwarzschild microscope of the ELETTRA Spectromicroscopy Beamline, working at the wavelength of 13.1 nm. Dedicated samples have been fabricated at the CEA-LETI facility in Grenoble, France. These microstructures consist in gratings of silicon oxide with depth ranging from 3 nm to 22 nm, on which we have deposited a multilayer of 40 pairs of Mo/Si. We will present recent results that demonstrate the ability of dark-field microscopy to detect buried structures as shallow as 3 nm. Moreover this experiment allowed to get a deeper understanding of the subtle imaging process of dark-field microscopy. This was made possible by an upgrade of the scanning stage, which was given the capability to tilt the sample. A fine tuning of the objective illumination by careful adjustment of the refocusing mirrors of the beamline has also provided a significant improvement of the images.

SAMPLE FABRICATION



PRINCIPLE OF DARK-FIELD MICROSCOPY



Case 1 : On a flat surface the incident light is reflected into the specular direction. No signal is detected by the photodiode.

Case 2 : The scattered light from the edge is detected by the photodiode.

RESULTS

Dark-field microscopy is a very sensitive technique, which allows to detect buried line defects as well as unintentional defects.

Buried line defect

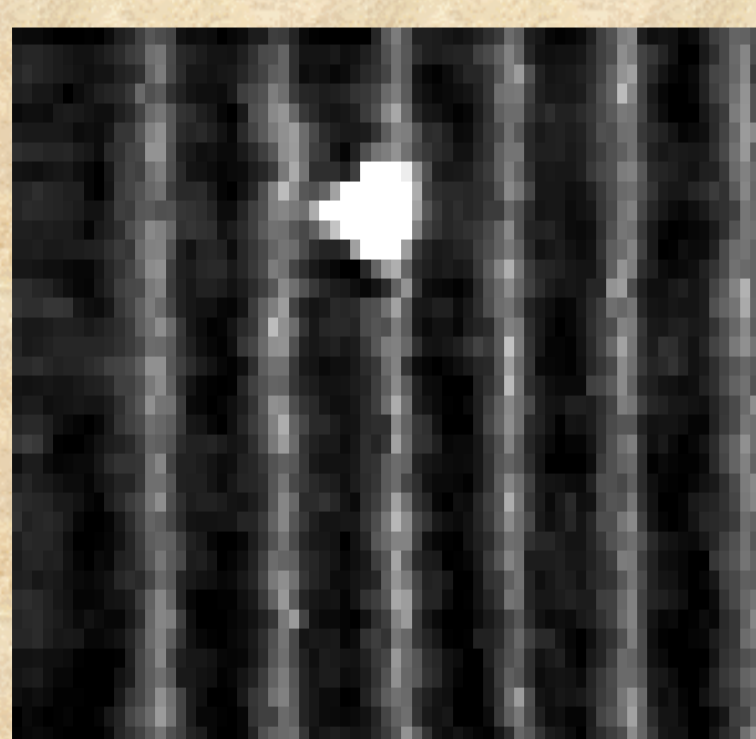


Image (21 μm x 22 μm) of a 3.2 nm height grating with an unintentional defect

Unintentional defect

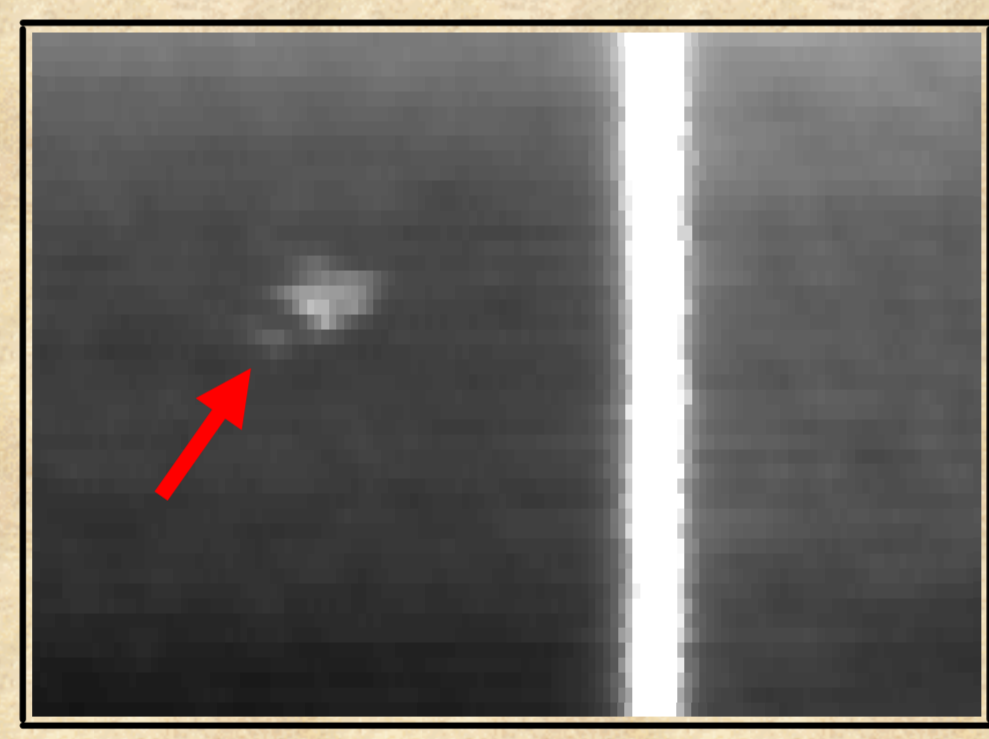


Image (18 μm x 13 μm) of an unintentional defect close to a step of 19.4 nm high. AFM measurements : size of 0.4 μm x 0.16 μm

Detection of buried defect as shallow as 3.2 nm high.

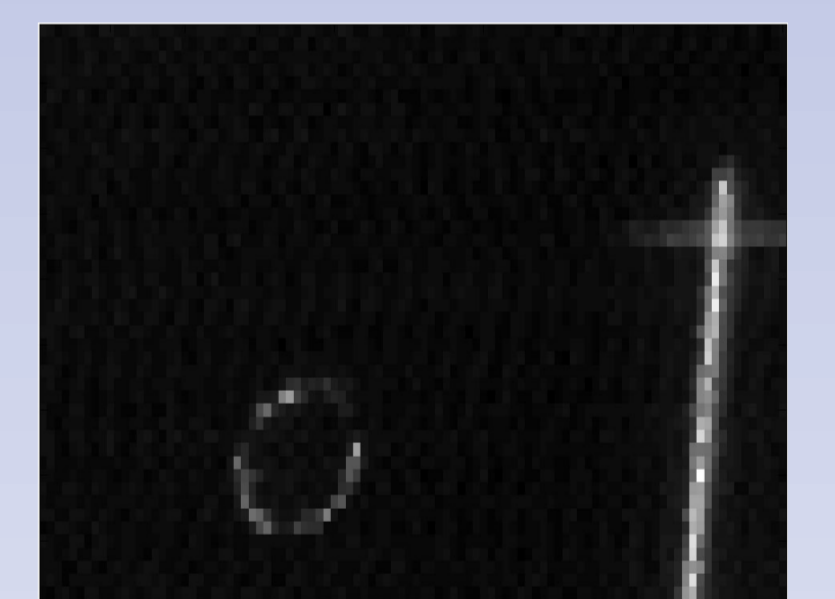
Good quality imaging of features with size well below the resolution limit (spot size = 0.5 μm)

POINT DEFECT IMAGING

The scattering light of a point defect (unintentional) reveals interesting imaging properties.



Image (35 μm x 30 μm) of a point defect near a step of 12.9 nm high at best focus

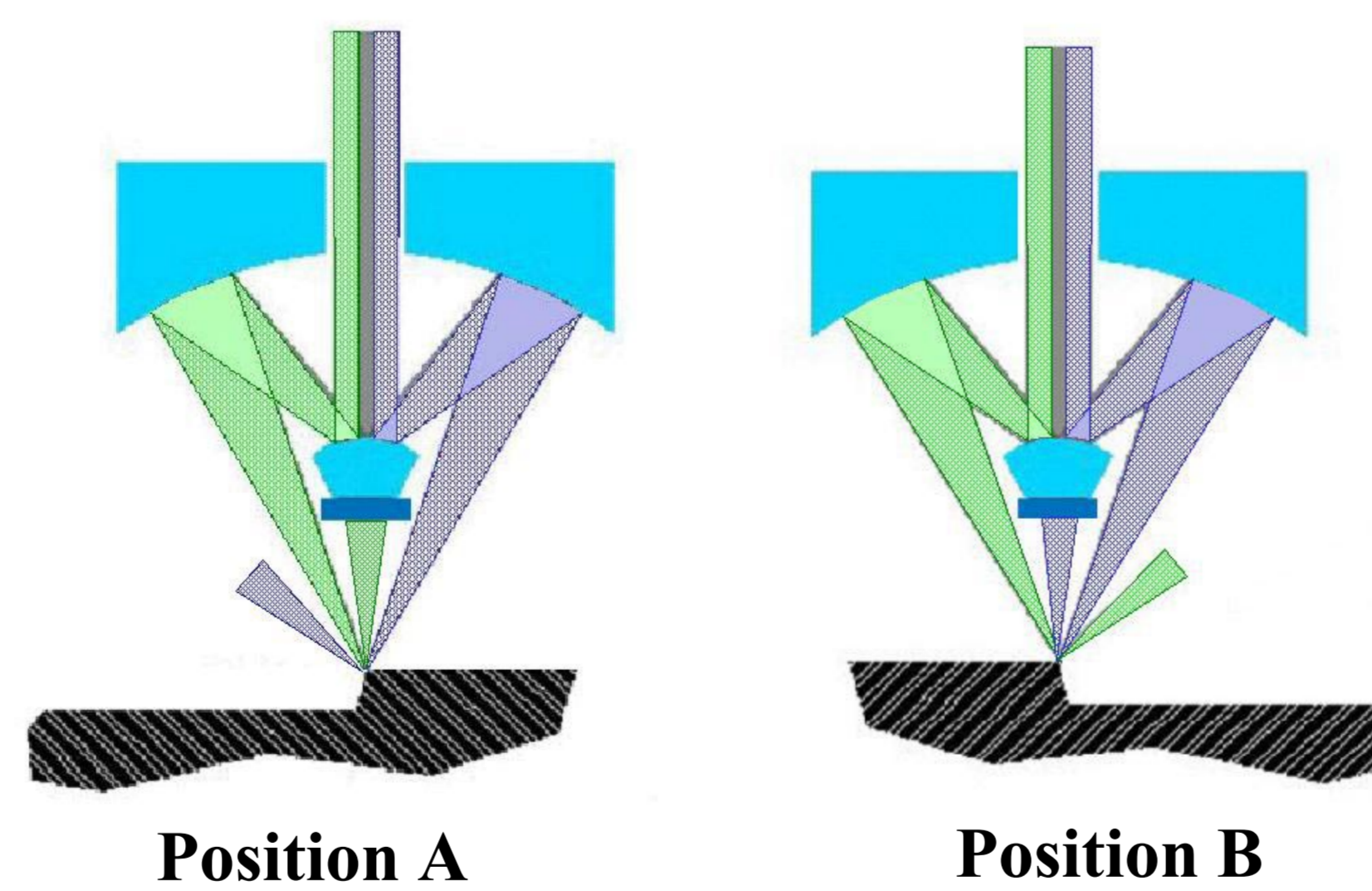
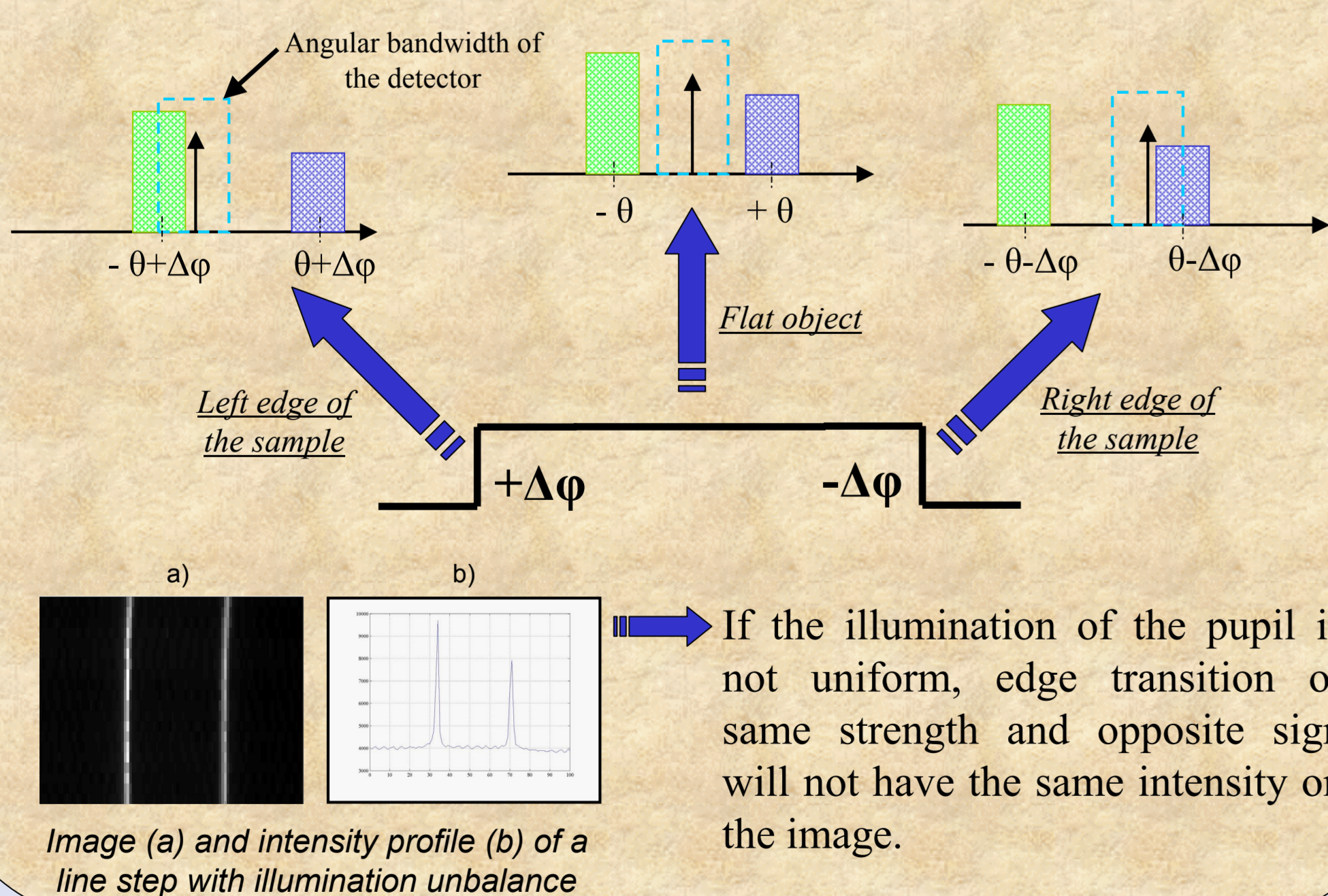


Same image out of focus

The defect acts as a scattering point, which permits to image the illumination pupil when out of focus.

IMAGE FORMATION MECHANISM

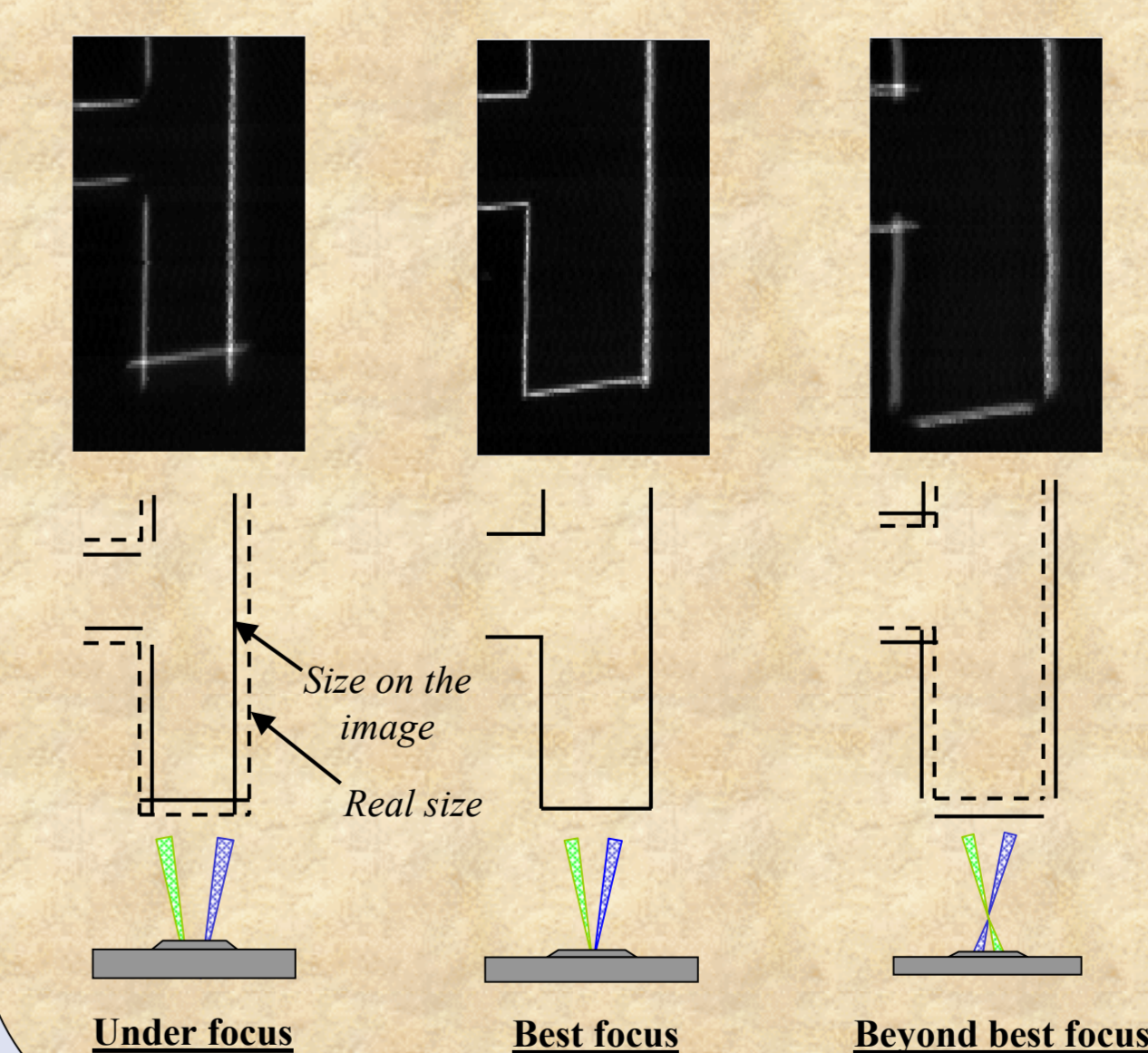
Illumination influence



Position A : Left slope is imaged by the left part of the illumination.

Position B : Right slope is imaged by the right part of the illumination.

Focus influence



Out of focus the spot on the sample is a « ring », when moving from position A to position B, the sample has to be scanned differently from its real size.

For example under focus, the sample is scanned by less than its real size; therefore it appears smaller in the scanning microscope

Conclusion

We demonstrated that dark-field microscopy is an extremely sensitive technique for the detection of multilayer buried defects: excellent contrast images were obtained on defects as shallow as 3 nm and with linear dimensions as small as 160 nm (imaging capability down to below 50 nm can be estimated). Even if large improvements are needed, especially in terms of speed, it appears to be very promising for the inspection of masks for the EUV lithography, which is one of the key technologies in next generations of integrated circuits fabrication.

New experiments are planned which will be dedicated to increasing the acquisition speed and investigating isolated defects with smaller sizes and, possibly, buried in a smoothing planarized multilayer, leading to a flat top of the mirror. The latter corresponds to the case of a potentially printable defect which could remain undetected when inspected at longer wavelength.