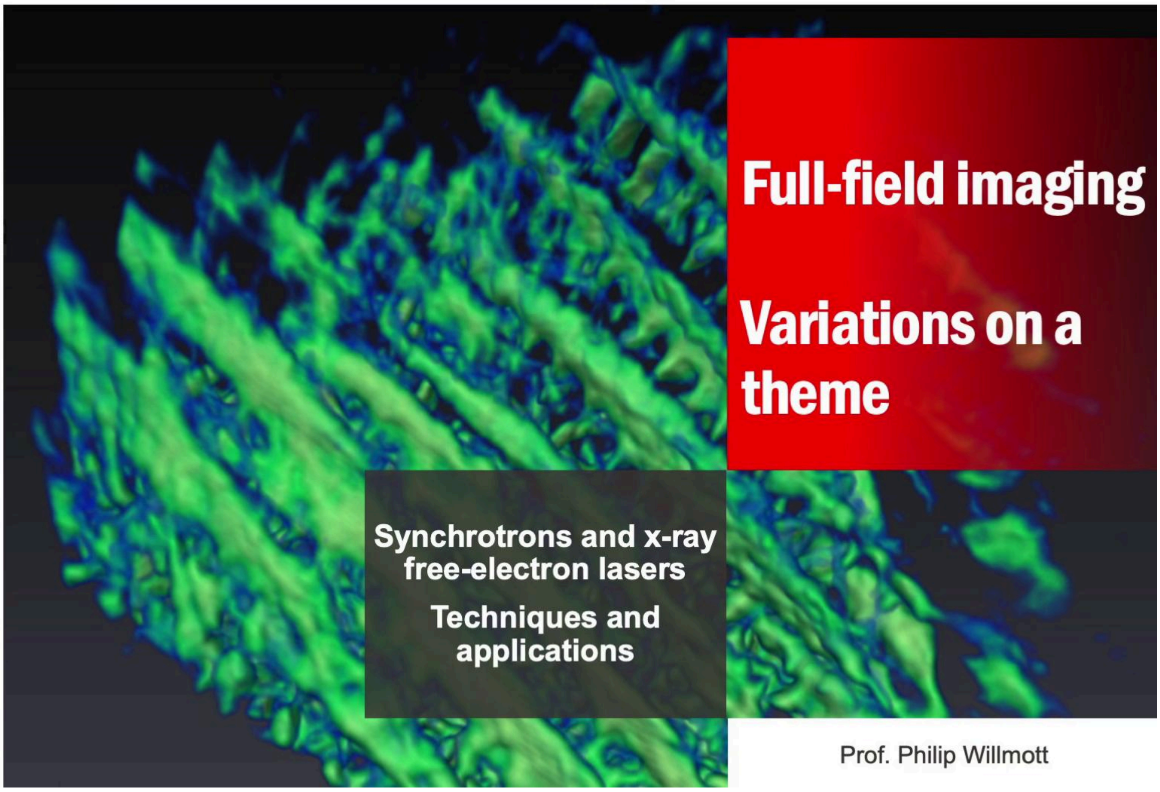
EPFL



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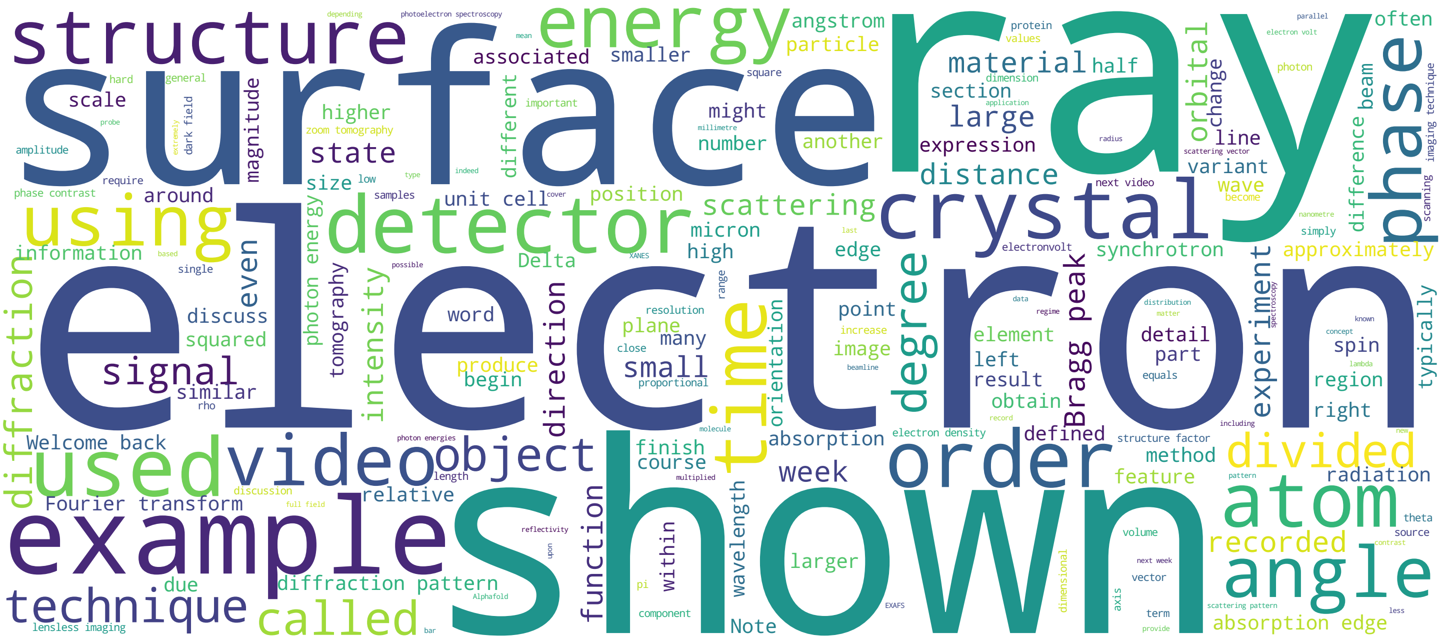


Search MOOC

Video

EPFL

Contents and objectives of this video

- Zoom tomography
- Chemical contrast
- Laminography

Welcome back. In this last video of the fifth week, we discuss zoom tomography, imaging with chemical contrast, and laminography.

Notes

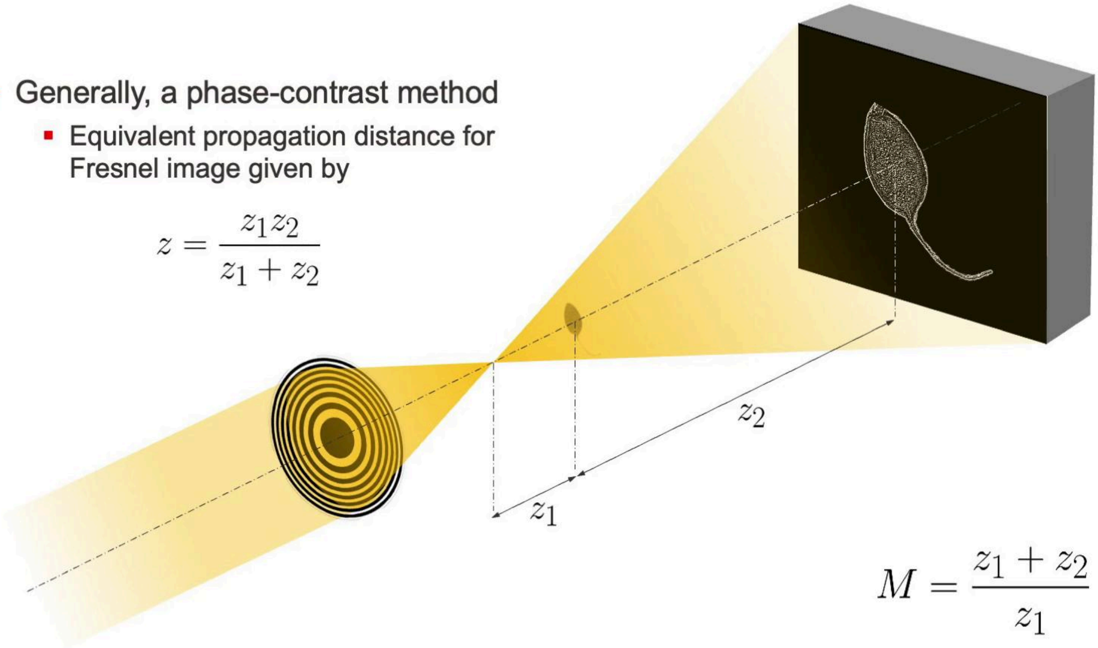
Summary

0m 05s

Zoom tomography

- Generally, a phase-contrast method
  - Equivalent propagation distance for Fresnel image given by

$$z = \frac{z_1 z_2}{z_1 + z_2}$$



$$M = \frac{z_1 + z_2}{z_1}$$

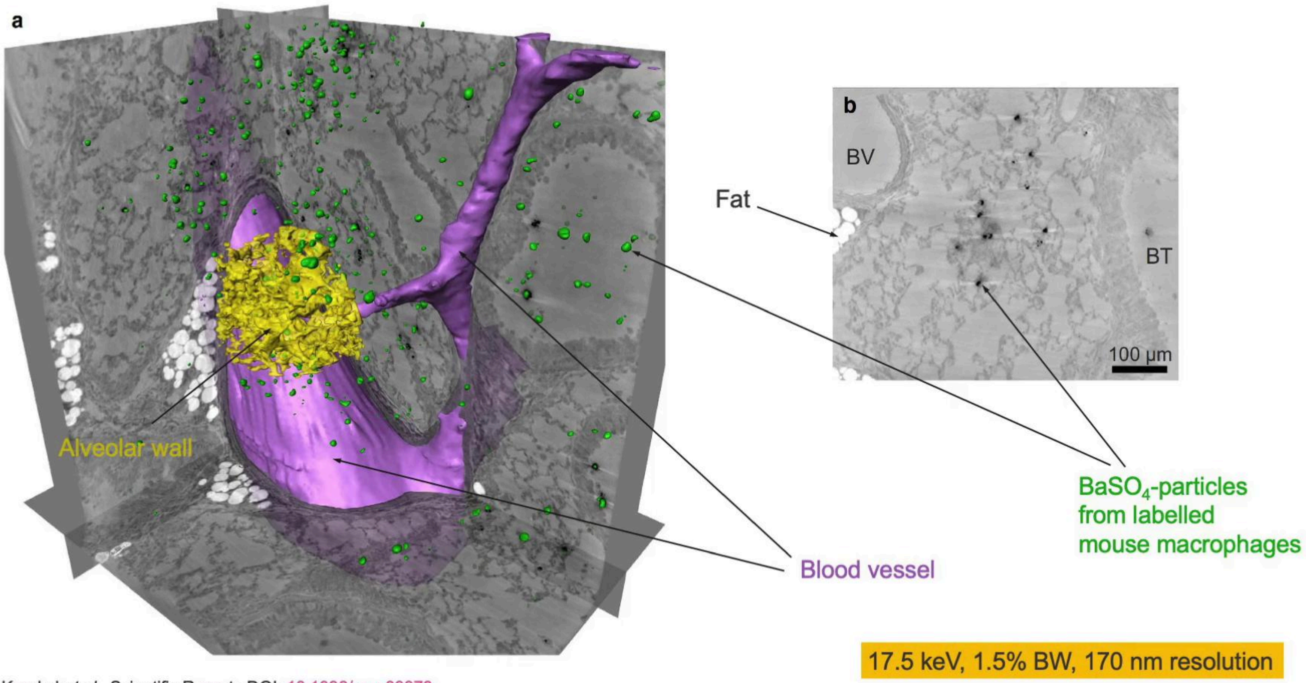
Zoom tomography is a simple variation of normal propagation-based, full-field tomography in which the sample is placed in a divergent beam and its phase-contrast projection is magnified onto a detector. The equivalent propagation distance for the captured Fresnel image is given by Z1 Z2 divided by Z1 plus Z2. The magnification factor is simply Z1 plus Z2 divided by Z1. Maximum resolutions lie at around 50-100 nanometres.

Notes

Summary

0m 16s

Zoom tomography example – asthmatic mouse lung tissue



17.5 keV, 1.5% BW, 170 nm resolution

M. Krenkel *et al.*, Scientific Reports DOI: 10.1038/srep09973

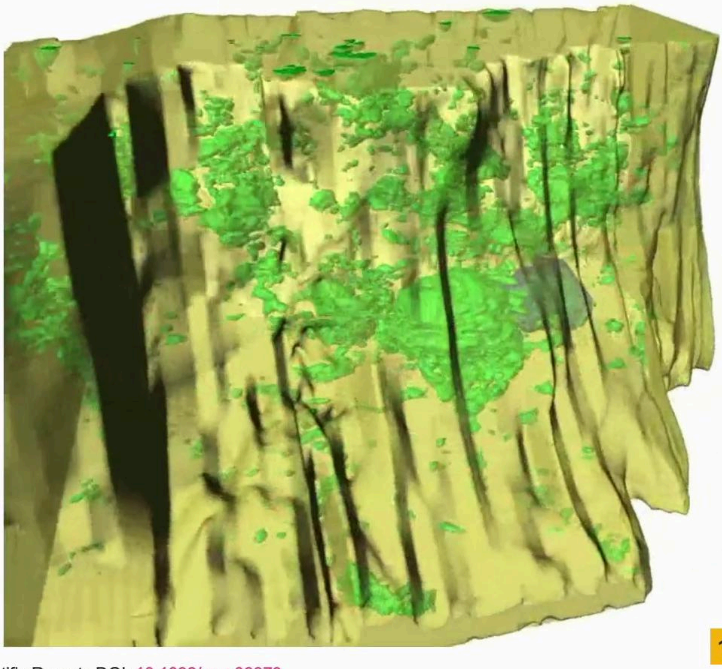
An example of zoom tomography is shown here, in which asthmatic lung tissue from a mouse was tomographically imaged. The 2D orthoslices show that barium-labelled macrophages are found mostly within the alveoli or lung sacs. The positions of the labelled macrophages or killer white blood cells suggest that they are mostly surrounded by soft tissue.

Notes

Summary

0m 53s

Zoom tomography example – asthmatic mouse lung tissue



17.5 keV, 1.5% BW, 170 nm resolution

M. Krenkel *et al.*, Scientific Reports DOI: 10.1038/srep09973

A higher resolution movie is shown here. The authors concluded that the macrophages are clearly located inside the bronchial wall, indicating that they are able to migrate through the bronchial epithelium.

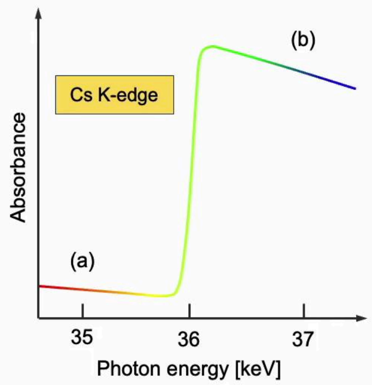
Notes

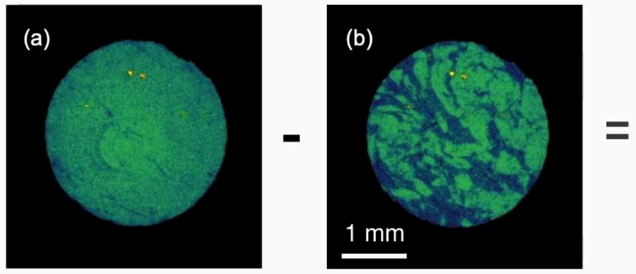
Summary

1m 22s

Chemical-contrast imaging and tomography

- Exploit sudden change in absorption near absorption edges





Diffusion of a 'contaminant plume' of caesium in a geological sample

Courtesy: D. Grolimund, Paul Scherrer Institute

By a judicious choice of photon energies, strong contrast can be achieved, even for heterogeneous materials with almost identical electron densities. By recording images below and above an absorption edge of a given element, as shown here for a contaminant plume of caesium in rock, the material containing that element is highlighted.

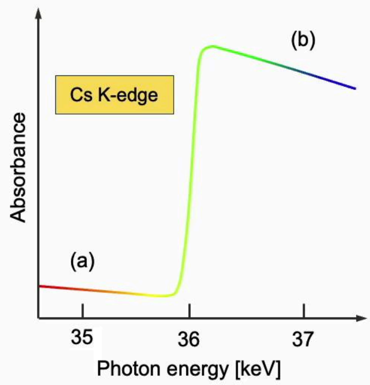
Notes

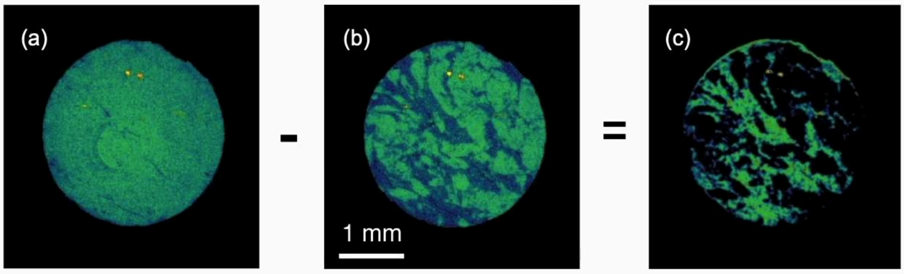
Summary

1m 45s

Chemical-contrast imaging and tomography

- Exploit sudden change in absorption near absorption edges





Diffusion of a 'contaminant plume' of caesium in a geological sample

Courtesy: D. Grolimund, Paul Scherrer Institute

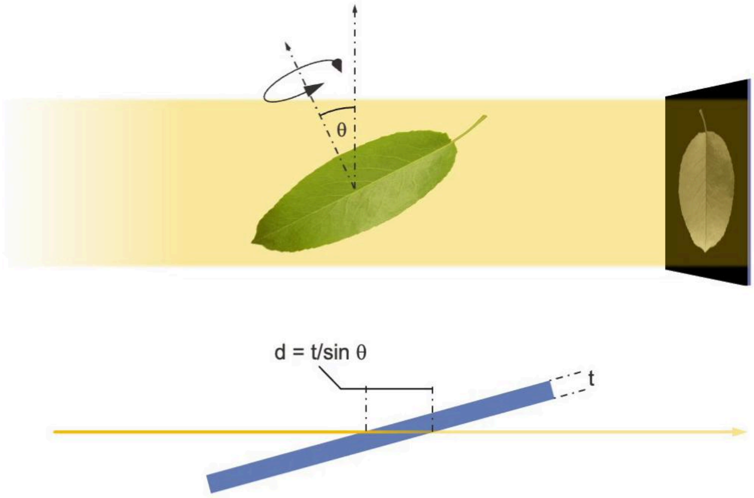
Note that by using left and right circular polarised radiation, magnetic dichroism can be similarly exploited, as we will see in next week's videos.

Notes

Summary

2m 08s

Laminography



- Variant of tomography used for flat samples
  - One characteristic length much smaller than the other two
  - If rotation axis ⊥ to x-rays, unacceptable variation in absorption
  - Tilt rotation axis by an angle θ
    - Make θ as small as possible compatible with

$$\frac{\sin\theta}{t} \sim \mu$$

We finish this video with a very brief description of laminography. This is a variant of tomography which is used for flat samples. In other words, samples in which one dimension is very much smaller than the other two, such as in a leaf or a silicon chip wafer. If the sample were rotated about an axis perpendicular to the incident beam, there will always be a certain range of angles in which the X-rays must travel through much larger distances in the sample than at other angles, no matter what the sample orientation is. This would result in an unacceptable variation of the degree of absorption. By tilting the rotation axis by an angle theta, a roughly homogeneous degree of absorption can be ensured. This should be adjusted to as small a value as possible, compatible with the condition that the inverse of the distance d is equal to t upon sine theta traveled by the X-rays through the sample of thickness t is similar in magnitude to the typical absorption coefficient of the sample mu. We will encounter again laminography next week when discussing lensless imaging techniques.

Notes

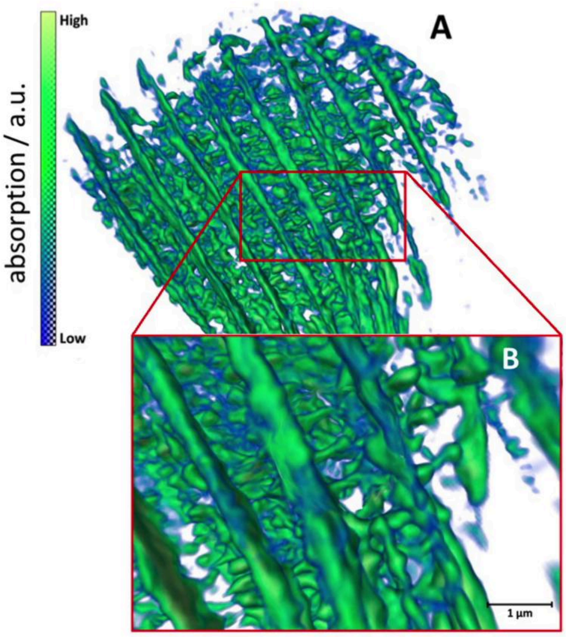
Summary

2m 19s

Laminography example – the architecture of butterfly scales

European Monarch. Image: Wikimedia Commons

K. Witte *et al.*, DOI: 10.1021/acs.nanolett.9b04782



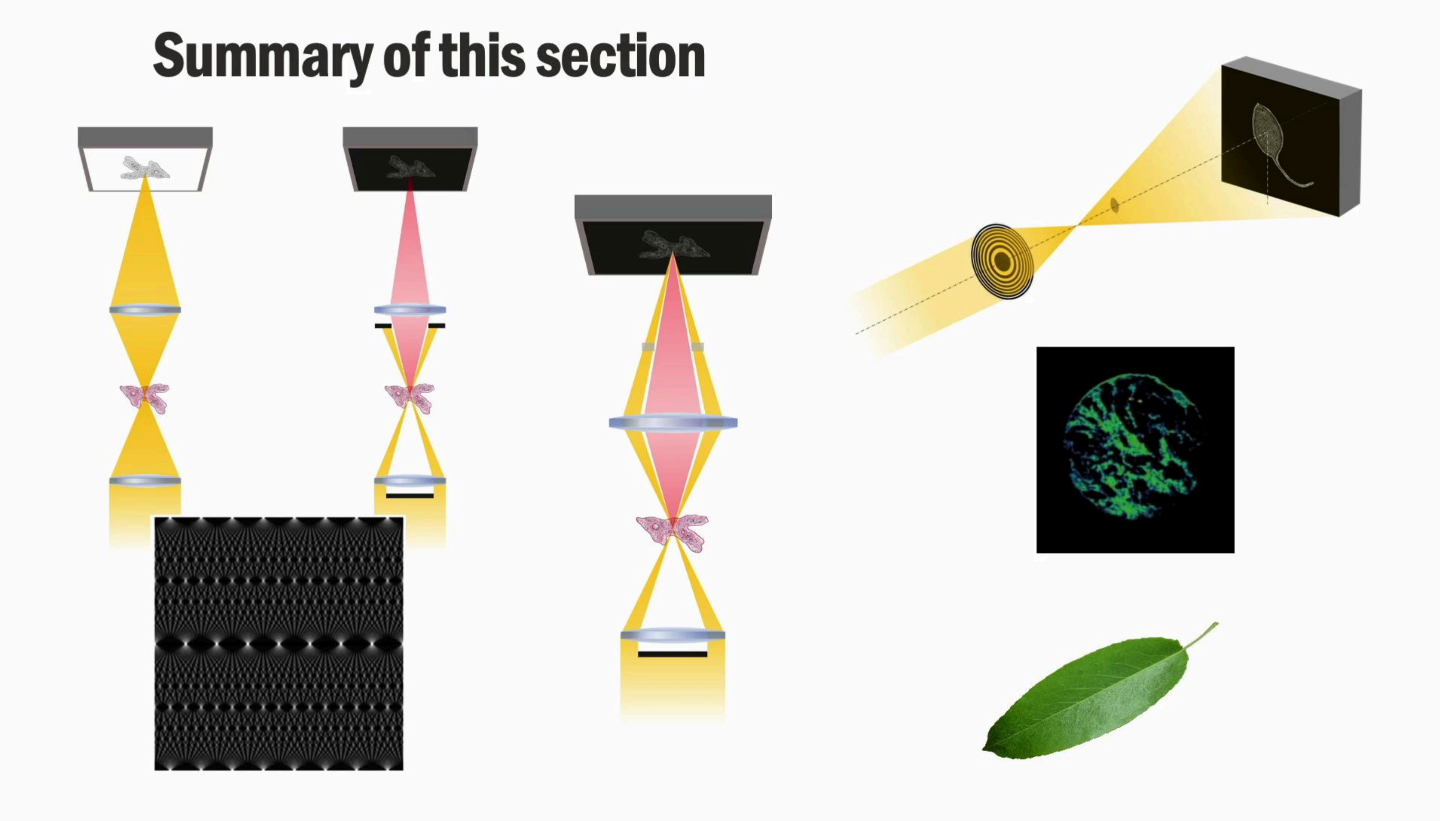
Ridges connected by crossribs

Laminography was combined with scanning X-ray transmission microscopy at the PolLux beamline at the Swiss Light Source to investigate the nano-architecture of the scales of a monarch butterfly. This showed how both lightness and rigidity were achieved by the long ridges forming the main struts of the scale being connected by nanometre-scaled cross ribs.

Notes

Summary

3m 40s



To summarise this last section of week 5, we encountered dark field microscopies based on scattering signal, distinct from bright field methods that are based on attenuation, plus variants of this using grating interferometry and exploiting the Talbot effect. We then went on to discuss Zernike phase-contrast microscopies zoom tomography, chemical contrast provided through recording images around element absorption edges, and finally, tomography of flat objects in a variant called laminography.

Notes

Summary

4m 04s

In our final sixth week, we will discuss lensless imaging techniques based on scattering, in which the far-field scattering patterns are recorded. These are in contrast to the methods that we have been discussing this week, which were all based on full-field propagation methods in classical tomography or use lenses in dark field, Zernike, and zoom microscopies.

Notes

Summary

4m 40s