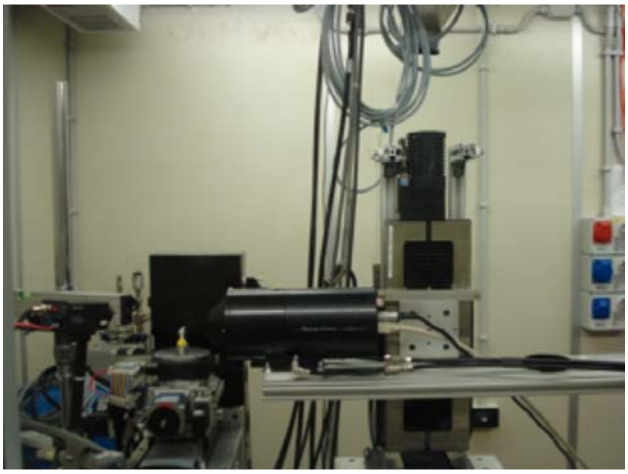
	CONSTGLASS	
	Technical Data sheet	

Technique :	**Synchrotron-radiation phase-contrast micro tomography**

General description



The SYRMEP experimental station

This technique allows non-destructive three-dimensional structural analysis with a spatial resolution down to 10 micron. The use of a spatially coherent X-ray beam allows detection of low-absorption materials usually invisible with conventional sources.

Phase contrast imaging

In conventional radiology the image formation relies on the X-ray absorption properties of the sample and can be expressed by means of geometrical optics. The image contrast is originated by a variation of density, composition or thickness of the sample and is based exclusively on the detection of amplitude variation of the transmitted X-rays. Information about the phase of X-rays is not taken into account.

The main limitation of this technique is the poor inherent contrast in samples with low-Z composition: indeed this is the case of "soft matter" which is considered, in the common sense, as *transparent* to X-rays.

Contrary to absorption radiography, "*phase-contrast* imaging techniques" are based on the observation of the *phase shifts* produced by the object on the incoming wave. They are described by means of wave optics.

Absorption and phase shifts are effects occurring to X-rays crossing any kind of materials. Their relationships is considered in the definition of the material complex index of refraction *n*, that in the X-ray region, slightly differs from unity: $n = 1 - \delta + i\beta$, where δ is related to the refractive properties and β determines the absorption. In the energy range between 15 and 25 keV, the phase shift term δ (of the order of 10^{-7}) can be up to 1000 times greater than the absorption term β (of the order of 10^{-10}), therefore it is possible to reveal phase effects even if the absorption is negligible (*phase objects*).

The observation of the local variations in the optical path-length, determined by variations of δ, is related to Fresnel diffraction.

In general, phase information can be accessed if the X-ray source has a high spatial coherence as happens for Synchrotron light sources like ESRF or Elettra.

Phase contrast approaches

Several approaches for *phase-contrast* radiology have been recently reported. Among these, the phase-contrast radiography technique based on free space propagation can also be called in-line holography in analogy with optic and has a quite simple application: the PHC set-up is the same of conventional radiography with the difference that the detector is positioned at a certain distance *d* from the sample. The X-rays exiting from the sample propagate in the free space until they reach the detector. Free space propagation transforms phase modulation of the transmitted beam into amplitude modulation. Contrast is originated from interference among parts of the wave-fronts that have experienced different phase shifts. According to the choice of *d* with respect to the size *a* of the feature to be identified perpendicularly to the beam direction, one may discriminate between two regimes: the edge detection regime ($d \ll a^2/\lambda$, where λ is the X-ray wavelength) and the holography regime ($d \approx a^2/\lambda$). In the edge detection regime images can be used directly to extract morphological information.
The produced diffraction pattern appears superimposed to the conventional absorption pattern (if any) on the detector and contributes mainly to enhance the visibility of the edges of the sample features.