CARNAÚBA: coherent x-ray nanoprobe for the Sirius-LNLS synchrotron light source

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CARNAÚBA (Coherent X-Ray Nanoprobe Beamline) is the tender-to-hard X-ray nanoprobe [1] under construction for the new source Sirius [2] at the Brazilian synchrotron light laboratory (LNLS). The beamline provides two separated experimental stations, one with sub-micrometer resolution and another with nanometer resolution, to cover various analysis techniques, including XRD, XAS, XRF, XEOL and CDI with 2D and 3D imaging capabilities exploring the coherent properties of the Sirius X-ray beam. An innovative modified-Delta undulator is optimized to provide photons with vertical polarization allowing for scattering in the horizontal plane from the source up to the end-stations. An in-house horizontal deflection four-bounce crystal monochromator (4CM) covers continuously the energy range from 2.05 to 15 keV, with a resolution of DE/E=10^{-4}. The all achromatic CARNAÚBA optics, based on state-of-the-art KB mirrors, delivers an unprecedent coherent flux @Si(111)BW close to 10^{+11} – 10^{+12} ph/s/100mA. The focus is nearly diffraction limited in the whole energy range: at the microprobe end-station the optics delivers a focus of 500 nm at 2.05 keV down to 100 nm above 8 keV, limited by a numerical aperture (2NA) of about 1.1 mrad; at the nanoprobe end-station the focus is around 120 nm at 2.05 keV and 30 nm above 8 keV, with 2NA$\approx$5 mrad. The nanoprobe station has the KB optics and sample environment in vacuum with a working distance of about 50 mm. A cryogenic sample holder and transfer system is under development. The innovative high-dynamic actuation on the vertical and horizontal KB mirrors provides a fast-scanning capability in the 10 to 100 Hz range for fast fly-scan operation. We estimate collecting a full 100$\times$100 ptychographic image in tens of seconds. On the other hand, the microprobe will have a more flexible sample environment and a much larger working distance, with nearly 350 mm from the horizontal mirror to the sample stage. The UHV environment of the KB mirrors is separated from the sample environment, whose holder is not in vacuum. Both end-stations will cover a large variety of scientific areas ranging from environmental, geophysical, agricultural, biological research to energy and more related to condensed matter areas. In this contribution, the CARNAÚBA detailed design and the construction progress will be reported. Many pieces of instrumentation have been developed at the LNLS and are under commissioning stage. Among the most important, the modified Delta undulator, a four-bounce crystal monochromator scattering in the horizontal plane, a secondary source aperture working under the pink beam and based on a cryogenically cooled silicon crystal, and finally a prototype sample manipulation system developed for the microprobe.

References

[1] Tolentino et al, Journal of Physics: Conf. Series **849** (2017) 012057

[2] webpage of the Sirius project - http://lnls.cnpem.br/sirius/?la=en