

Enhanced temperature and gas options at Bessy II beamline KMC-2

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At the Berlin synchrotron BESSY II, the KMC-2 beamline [1] serves two permanent experimental stations, "XANES" and "DIFFRACTION". A graded SiGe monochromator provides radiation in the energy range of 4 – 14 keV with energy resolution of 1/4000 and beam intensity stabilized to an accuracy of 0.3 %. XANES uses this high-quality radiation for EXAFS and X-ray fluorescence measurements. The six-circle goniometer of the DIFFRACTION station can be set up for a wide range of scattering and diffraction measurements, including grazing incidence diffraction (GID), reciprocal space mapping, diffuse scattering, anomalous diffraction, and powder diffraction. The time needed to switch between XANES and DIFFRACTION is only two hours. This makes it possible to combine both stations in the same experiment, making KMC-2 a very versatile beamline especially suited for a wide range of non-standard experiments.

A particular strong point of KMC-2 is the wide range of sample environments available for both stations. Besides various high-temperature furnaces and gas-loading devices, of particular interest for crystallographers are the newly developed temperature environments [2], which allow experiments in a wide temperature range in vacuum or in controlled gas atmospheres:

CCR-XRD is based on a Gifford-McMahon (GM) closed-cycle cryocooler equipped with a high temperature stage, which covers the temperature range from 15 K to 450 K for samples in vacuum. At temperatures lower than 320 K an optional Kapton cupola can be used to keep the sample at inert or exchange gas conditions. Exchanging the Kapton cupola for a Beryllium dome allows investigating samples at controlled gas atmospheres up to pressures of 150 kPa and up to 450 K. The equipment can be used both in transmission or reflection during diffraction studies and in transmission or fluorescence XAS experiments. Of particular interest is the ability for seamless studies of phase transitions around ambient temperature.

For small samples, several capillary setups are available. The CRYO-GAS-JET system applies a cryogenic generated gas jet to a glass or Kapton sample tube in a setup designed to prevent ice condensation. This system allows a temperature range of 20 - 300 K. An AROUND-AMBIENT- and a HOT-AIR-JET setup use special gas thermalized capillary environments designed to provide very homogeneous temperature profiles, in the temperature ranges 250 – 320 K and 300 - 700 K, respectively. All capillary systems allow sample rotation for enhanced particle statistic, and also allow applying a continuous flow or static gas atmospheres up to 10.000 kPa to the sample.

All sample environments are available to users of KMC-2 @ BESSY II. They have been successfully utilized in a wide range of experiments and are under constant development.

[1] Helmholtz-Zentrum Berlin für Materialien und Energie. (2016). KMC-2: an X-ray beamline with dedicated diffraction and XAS endstations at BESSY II. *Journal of large-scale research facilities*, 2, A49.

[2] <https://www.helmholtz-berlin.de/user/experimental-infrastructures/sample-environment/se-at-bessy/temp-environment-kmc2/>

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