MONOCAPILLARY DEVELOPMENTS AND APPLICATIONS AT CHESS

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Hollow glass tubes are in use at CHESS as x-ray optics in the 5 to 15 keV range to take larger diameter, fairly parallel x-ray beams and compress them into smaller diameter, more divergent beams for various kinds of x-ray applications. The optics come in two forms 1) multibounce condensing capillaries for making submicron diameter beams and 2) one-bounce imaging capillaries with working distances of 20 to 50 mm from the tip of optic to the focal spot.

Condensing applications: The x-ray focal size out of a condensing capillary is dependent on the opening of the capillary tip and not too much related to the capillary figure accuracy. Therefore is relatively easy to make sub-micron scale x-rays for micro-beam x-ray experiments. We used one condensing capillary with a 0.8 micron tip opening to image the Zn K alpha distribution in a single plant cell via x-ray fluorescence. In another similar experiment, the Ga to As composition profile ratio was measured in a thin semiconductor film and shown to vary laterally during Selective Area Growth studies.

Imaging applications: The focal spot size of a one bounce capillary is a demagnified image of the synchrotron source blurred out slightly from small residual slope errors (80 to 150 microradians) from capillary manufacture. It is not directly related to the capillary tip opening. The elliptical shape is chosen once the upper working x-ray energy, maximum divergence, and working distance from the tip are known. We then manufacture a custom capillary on our in-house drawing machine. We have developed various sizes of one bounce capillaries, with spot sizes from under 10 μm to about 20 μm, focal distance from 30 mm to 55mm, divergence angles from 2 mrad to 4 mrad, and the optimal elliptical figures for CHESS A2, B1, B2, D, and F2 stations. Typically, the capillary length is 100 mm, the reflectivity is >90%, the gain in flux/unit area is 10 to 200 depending on the experimental requirements.

The preliminary results of the applications, from high-pressure powder diffraction and XAFS in diamond anvil cells to protein crystallography will be briefly described in this overview paper.