Optimizing Monocapillary Optics for Synchrotron X-ray Applications

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1. Introduction to monocapillary optics
2. Elliptical focusing one-bounce geometry
3. CHESS applications experience
   a) Fluorescent imaging of fish ear stones
   b) Confocal x-ray microscopy of historic paintings
4. Conclusions
What can optics do?

Magnification = \frac{F_2}{F_1}; \text{ Divergence } \sim \frac{D}{F_2} \sim 0.5^\circ \ (9 \text{ mr})
Introduction to Monocapillary Optics

Why do we need a capillary?

To make small beams and to increase the x-ray beam intensity (flux/\mu m^2)

What kind of capillaries we are talking about?

One-Bounce Glass Capillary

- Large working distance (cm scale); Good
- Near 100% transmission; Good
- Divergence controlled by making ideal mathematical shape; Good
- More difficult to make small focal spot, (such as 1 \mu m); Challenge!
Life History from Fish Ear Stones

Optical image of an otolith of blueback herring captured in the Mohawk River at Rome, NY

Barium is present only in the interior, corresponding to the first season's growth. The high Sr ring is consistent with going out to sea. The three tracers confirm that the fish life began in the Mohawk, spent one winter out at sea and then returned to a lower estuary.

New Tool for Art History


Confocal x-ray fluorescence microscope analyzes buried layers non-destructively

UNIQUE PROGRAMS → unique facility combining x-ray and art scientists (NSF IMR grant)

IMPACT → demonstrates state-of-art quantitative analysis
**New and Improved DB3 glass puller**

**Goal:** highly automated puller with fast optical profile analysis to be used in conjunction with web-based capillary design program (developed by Rong Huang)

**New puller design team:** Don Bilderback, Tom Szebenyi, Sterling Cornaby and Aaron Mauer

**Furnace translation:** linear air bearing with 0.1 micron readout

**Strain gauge/tensioning method** with 0.02 gram resolution at 100g (force) of total tension.

**New furnace and temperature controller** control to 0.3 C

**Velmex tensioning stage** pulls upward as glass yields to maintain a constant tension

**LabView** operating under WinXP controls the equipment

**Keyence dual-axis Optical Micrometer** measures the outer glass profiles either before or after drawing