MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Ralf K. Heilmann, Ph.D.
Research Scientist
Space Nanotechnology Laboratory
Center for Space Research
Email: ralf@space.mit.edu

77 Mass. Ave., Room 37-421
Cambridge, MA 02139-4307
USA
Phone: 617-253-8764
Fax: 617-452-2888

Re: Final Technical Report for Contract # NCC5-330 (OSP Acc# 6704200): Development of Accurate Structure for Mounting and Aligning Thin-Foil X-Ray Mirrors

TO: Joan Boughan
FROM: Ralf Heilmann
DATE: Sept. 3, 2001

The goal of this work was to improve the assembly accuracy for foil x-ray optics as produced by the high-energy astrophysics group at the NASA Goddard Space Flight Center.

Two main design choices lead to an alignment concept that was shown to improve accuracy well within the requirements currently pursued by the Constellation-X Spectroscopy X-Ray Telescope (SXT).

The first choice was the separation of metrology frame (for accurate alignment) and flight frame (structural support for launch and operation in space). This allows for relaxed requirements on the flight frame and for reuse of the advanced high accuracy alignment structures which are removed after assembly.

The second choice was to utilize fabrication techniques developed from lithographic processes used in the MEMS (micro electro-mechanical systems) industry that provide the required sub-micron accuracy for the alignment of the foil-optics.

We designed, built, and tested novel silicon structures called microcombs that hold x-ray foil optics in place with sub-micron accuracy during assembly. The combs apply the necessary force to hold foil optics accurately and with minimal distortion during gluing to the flight frame. At the same time they can accommodate predicted variations in foil thickness without compromising alignment.

We built a metrology station for nested flat foils and successfully tested the mounting and alignment scheme described above. Positioning tolerance was found to be better than 0.5 micron, resulting in an angular resolution of ~ 1 arc second for the Constellation-X design.

Related publications and reports:

G. P. Monnelly, D. Breslau, N. Butler, C. G. Chen, L. M. Cohen, W. Gu, R. K. Heilmann, P. T. Konkola, O. Mongrard, G. R. Ricker Jr., and M. L. Schattenburg
High-Accuracy X-Ray Foil Optic Assembly
X-Ray Optics, Instruments, and Missions IV, R. B. Hoover and A. B. Walker (eds.), Proc. SPIE 4138, 164 (2000).

C. G. Chen, L. M. Cohen, R. K. Heilmann, P. T. Konkola, O. Mongrard, G. P. Monnelly, and M. L. Schattenburg
Micro-Comb Design and Fabrication for High-Accuracy Optical Assembly
J. Vac. Sci. Technol. B 18, 3272 (2000).

O. Mongrard et al.
Assembly Truss Results #1: Rigid Flat Plate Tests
Report to GSFC on May 1, 2000.

O. Mongrard,
X-Ray Telescope Prototype
Internship Report, August 1999

Related Presentations:

"Microcomb design and fabrication for high accuracy optical assembly," C. Chen, O. Mongrard, L. Cohen, R. Heilmann, P. Konkola, G. Monnelly, and M. Schattenburg, poster presented at the *MIT Microsystems Technology Laboratories Student Research Review,*
Dedham, Massachusetts, January 10, 2000.

"Microcomb design and fabrication for high accuracy optical assembly," C. Chen, L. Cohen. R. Heilmann, P. Konkola, O. Mongrard, G. Monnelly, and M. L. Schattenburg, presented at the *44 th International Conference on Electron, Ion and Photon Beam Technology & Nanofabrication,*
Palm Springs, California, May 30-June 2, 2000 *(paper 16-4)*.

"High-accuracy x-ray foil optic assembly," G. P. Monnelly, D. Breslau, N. Butler, C. C. Chen, L. Cohen, W. Gu, R. K. Heilmann, P. T. Konkola, O. Mongrard, G. R. Ricker, and M. L. Schattenburg,
presented at *SPIE's 45 th Annual Meeting, Exhibition and Education Program,*
San Diego, California, July 30-August 4, 2000 *(paper 4138-23)*.