A Twenty-Five-Actuator Optical Surface Bender for Ultra-High Resolution Soft X-ray Spectroscopies

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To facilitate ultra-high resolution soft X-ray spectroscopies in angle-resolved photoemission (ARPES) and resonant inelastic X-ray scattering (RIXS), a 25-actuator optical surface bender has been designed, constructed and tested. The mechanical design of the bender is based on a novel high precision, high resolution flexure hinge adjustment system. Among the 25 actuators, 6 of them are for controlling the surface major profile by setting positions, while the remaining 19 actuators are for fine tuning the shape by setting forces. The long tracing profiler measurements show that, before bending, the intrinsic surface slope error of the flat mirror or grating is around 0.6 μrad full-width-root-mean-square (FWRMS). By using all 25 actuators of the bender and an unique adjustment algorithm, the slope error can be reduced down to 0.2 μrad FWRMS for any radius of curvature set between 45 m to 300 m with a desired complex shape; in the best case, a slope error of 0.06 μrad FWRMS has been achieved, implying theoretically that the energy resolving power of the ARPES and RIXS can reach beyond 140,000 and 100,000 in soft X-ray spectral region, respectively. The bender can also be used to eliminate the slope error caused by thermal deformation set off by the synchrotron radiation heat load, preserving the ultra-high resolution of these spectroscopies.