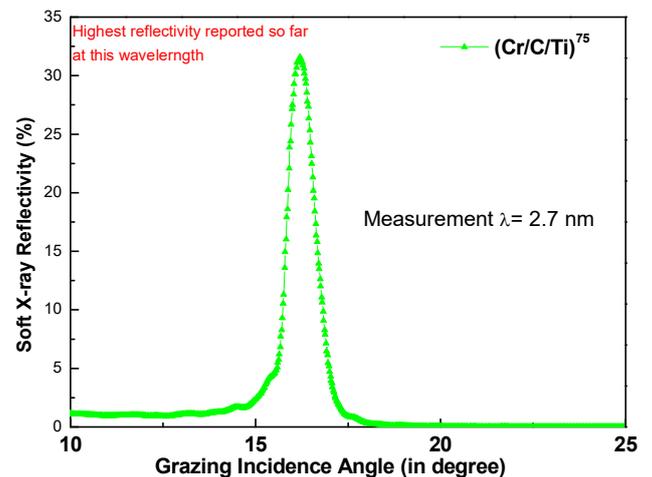
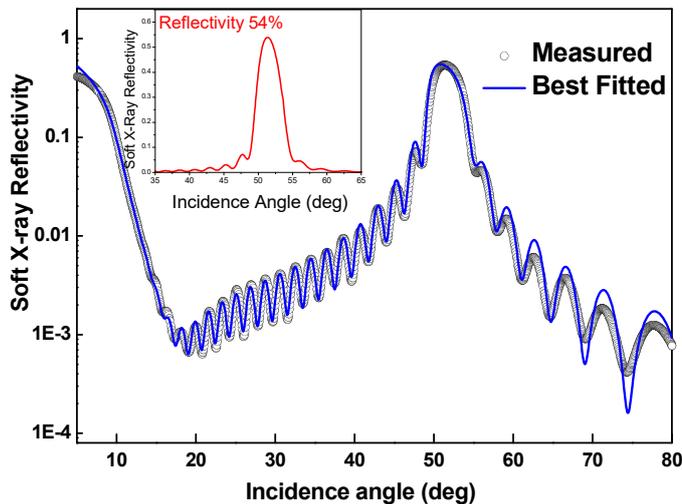


- Development of multilayer soft X-ray mirrors (2017-2020)



**Soft X-ray mirrors need much higher thickness control since individual layers are sub-nm thick and roughness of the layers should be below 0.3 nm. To achieve this, ion beam sputtering (IBS) is the best technique since in IBS the energy of adatoms is high and so it gives compact films with bulk-like density and very low roughness. The assist ion gun of the dual ion beam sputtering system is used to project a beam of ions on the substrate to impart higher momentum on the adatoms of growing films so that still smoother and denser films can be obtained. We have installed a state-of-art DIBS system in our laboratory (top panel) and using this system we have already developed several very good quality thin film multilayer samples having important technological applications in soft X-ray regime. For example, 25 bi-layer Mo/Si multilayers deposited with C barrier layer at each interface has been found to yield very high reflectivity of 54% at 13 nm soft X-ray wavelength (bottom panel left) and can be used in Soft X-ray/EUV lithography systems. Cr/Ti multilayers with bi-layer spacing of ~ 4.0 nm, Cr to bi-layer thickness ratio of 0.40 and 0.3 nm C barrier layer at Cr-on-Ti interface are also found to yield high reflectivity ~ 31.6% at 2.8 nm soft X-ray wavelength (bottom panel right) which is the highest reflectivity reported so far in the literature in this wavelength regime and this multilayer can be used as a mirror in the “water window” soft X-ray region.**