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Understoichiometric CrBx/TiBy superlattices as novel materials for neutron mirrors

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The reflected neutron flux from state-of-the-art neutron multilayer mirrors is hampered primarily by insufficient layer definitions. To achieve the ultimate flat and abrupt interfaces (±½ atomic layer), the mirror should be made as a single crystal, artificially layered, heteroepitaxial structure (superlattice, SL). Here we explore CrBx/TiBy (0001)/Al2O3 (0001) SL mirrors, grown by magnetron sputter epitaxy.
We study the effect of composition on the interface quality and neutron reflectivity of CrBx/TiBy SLs with periodicities $\Lambda \approx 6$ nm and TiB2 thickness-to-Λ ratios, $\Gamma \approx 0.3$, 0.5, and 0.7, grown from two set of target composition. Elastic recoil detection analysis shows overstoichiometric (B/TM > 2) SLs for one set of target materials and understoichiometric (B/TM < 2) for another set of targets. X-ray diffraction, X-ray reflectivity, and high resolution scanning transmission electron microscopy show that understoichiometric SLs exhibit significantly higher structural quality and smaller interface widths compared to overstoichiometric ones. Neutron reflectivity simulations using the GenX code show that small changes in B composition affect the neutron scattering length density of the SLs so that understoichiometric SLs exhibit higher neutron reflectivity with a different low intensity variation. Such structures have the potential to be used as novel materials for the compact slit package (~20×30 mm2) that is required for supermirror Fermi choppers.

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