Epitaxial Growth and Characterization of Mo/NbN and W/NbN superlattices

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Mo/NbN and W/NbN superlatttices with modulation wavelengths from 1.4 nm to 25 nm were grown on MgO(001) substrates by reactive d.c. magnetron sputtering. These superlattices represent a new class of non-isostructural superlattice in which a body-centred cubic metal is combined with a B1-structure nitride. Epitaxy is achieved because of the small lattice mismatch(1.4% for Mo/NbN and 2.0% for W/NbN) between the (001) planes after a 45° rotation about the normal. The epitaxial relationship Mo(001)||NbN(001), Mo[110]||NbN[100] was verified by pole figure scans and selected area electron diffraction patterns. Auger scans showed little nitrogen in the metal layers, despite sputtering in a nitrogen-containing ambient because of the 800°C growth temperature. High angle x-ray diffraction results show up to 25 satellite reflections extending over a wide range $\approx 30°$ of 2θ values because of the large difference in out-of plane lattice spacings. Computer simulations (based on a kinematical model and a trapezoidal compositon modulation) of the high angle XRD data suggest that the interface widths were ≤ 0.3 nm, presumably because of the immiscibility of the metal and NbN. Low angle XRD patterns show up to 16 peaks (for $\Lambda \sim 16$ nm) for the W/NbN superlattices and dynamical theory simulations estimate the roughness to be ~ 0.2 nm. Cross-sectional transmission electron microscope images of Mo/NbN superlattice show well-defined and relatively planar layers.