In-situ synchrotron HRXRD investigation of epitaxial YSZ/Ti/Pt/BaFe12O19/ Bi3Ti5FeO15 multiferroic heterostructures on Si(111) for non-volatile memory applications

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We present a comprehensive in-situ synchrotron high-resolution X-ray diffraction study of a five-layer heterostructure — YSZ/Ti/Pt/BaFe12O19(BaM)/Bi3Ti5FeO15(BTFO) — grown by pulsed laser deposition (PLD), performed at the NANO beamline of the KARA synchrotron facility at KIT. At each growth step, rocking curves are recorded while a Pilatus 2M area detector simultaneously captures the full large-angle two-dimensional diffraction pattern. Maximum intensity extraction along detector lines yields a comprehensive diffraction profile in which symmetric coplanar reflections, parasitic phases, polycrystallinity, and the textured nature of BTFO are all monitored in a single scan, drastically reducing acquisition time and demonstrating the capability of in-situ synchrotron HRXRD as a uniquely efficient diagnostic for complex multiferroic heterostructure growth. Multiferroic heterostructures combining ferromagnetic and ferroelectric layers are promising candidates for high-temperature non-volatile memory (NVM) devices exploiting magnetoelectric coupling. Translating such architectures from single-crystal oxide substrates to industry-standard Si(111) wafers requires a complex multilayer buffer strategy whose structural evolution must be understood at every deposition step. The sequential in-situ approach enables direct identification of how each template constrains the texture and phase purity of the subsequent layer. The yttria-stabilized zirconia buffer establishes (111)-oriented epitaxy on Si(111), while the Ti and Pt interlayers provide the adhesion and lattice mismatch template required for growth of the functional oxide bilayer. The ferromagnetic BaM layer grows c-axis oriented on Pt(111), leveraging the hexagonal symmetry match, as confirmed by the evolution of (00l) reflections in the in-situ RSMs. The Aurivillius-phase BTFO presents the principal crystallographic challenge, being inherently prone to polycrystalline nucleation and thus requiring precise control of both deposition parameters and template quality to achieve preferential orientation. Through systematic optimization of PLD parameters for each layer on its respective template, we demonstrate near-single-oriented BTFO films with suppressed polycrystalline grain orientations. In-situ RSMs and rocking curve analysis identify the deposition parameters that favor oriented over polycrystalline BTFO nucleation. These results represent a significant step toward integrating Aurivillius-phase multiferroic heterostructures on silicon platforms for scalable, high-temperature NVM technology.