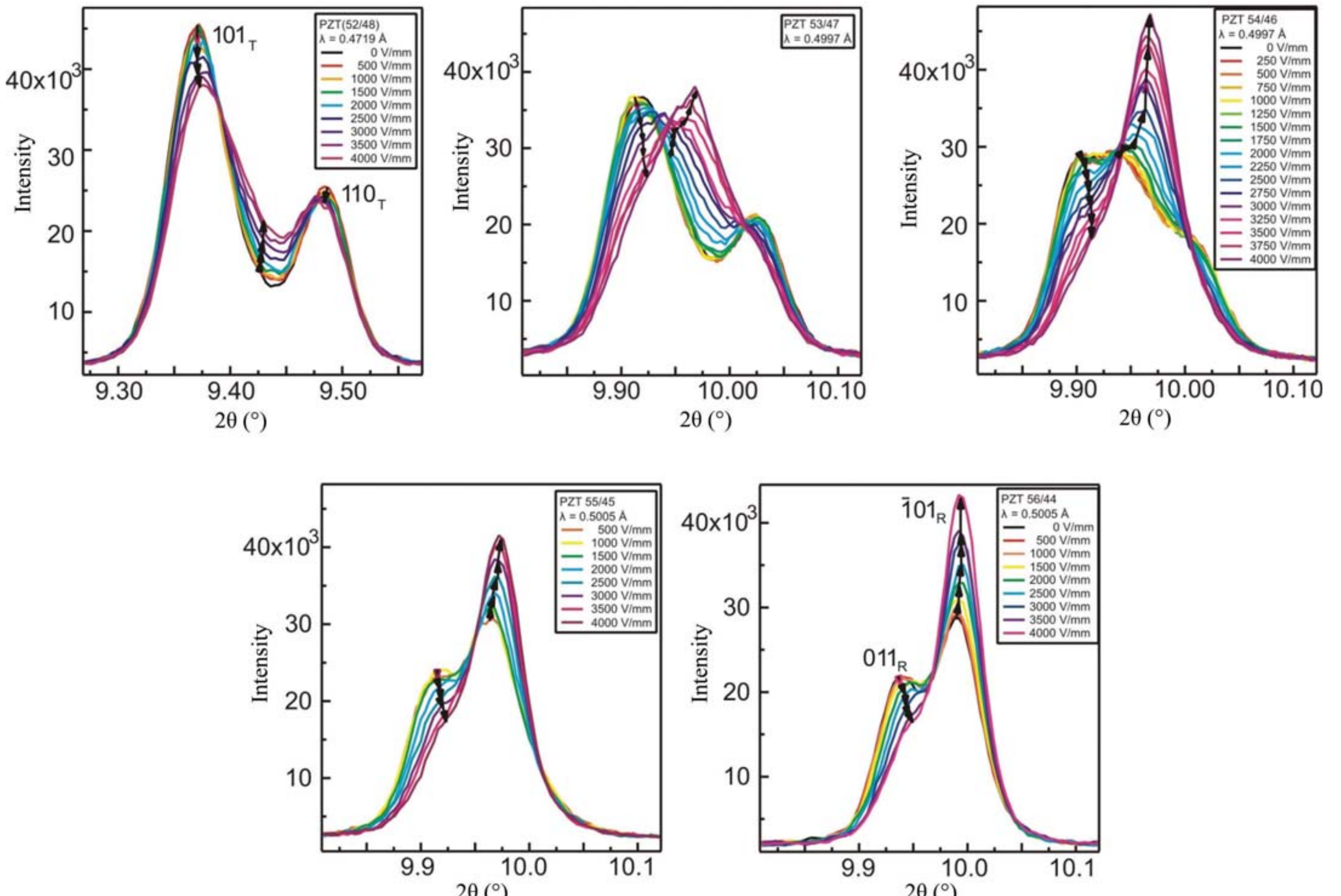

Figure 2.8.3
Diffraction patterns of the tetragonal 101_T /110_T reflection pairs of PZT 52/48, PZT 53/47, PZT 54/46, PZT 55/45 and PZT 56/44 recorded *in situ* under an electric field for the first poling cycle of up to 4 kV mm^{-1}. Reproduced with permission from Schönau, Knapp *et al.* (2007). Copyright (2007) by the American Physical Society.

in the range of seconds are necessary to ensure sufficient statistics for single diffraction experiments in the subsecond regime. Stroboscopic measurements can be used to achieve this.

Absolutely reversible processes are necessary for a successful stroboscopic analysis. The stability of the system is achieved by pre-cycling *circa* 10^5 times. Time resolutions in the range of several tens of milliseconds are possible with modern X-ray detectors. By repeating the excitation and summing the intensities, proper statistics can be achieved (Choe *et al.*, 2015; Hinterstein *et al.*, 2014).

The use of the stroboscopic data-collection technique and cyclic fields in neutron diffraction experiments enabled a direct measurement of non-180° domain wall motion during the application of subcoercive cyclic electric fields (Fig. 2.8.8) (Jones *et al.*, 2006, 2007; Jones, 2007; Daniels *et al.*, 2007). It was shown that the non-180° domain switching contributes 34% of the macroscopically measured strain during cycling with half of the coercive field.

The highest time resolutions are obtained in a pump–probe setup. Under the influence of an electric field of 2 kV mm^{-1}, the switching kinetics can be investigated directly. With a time

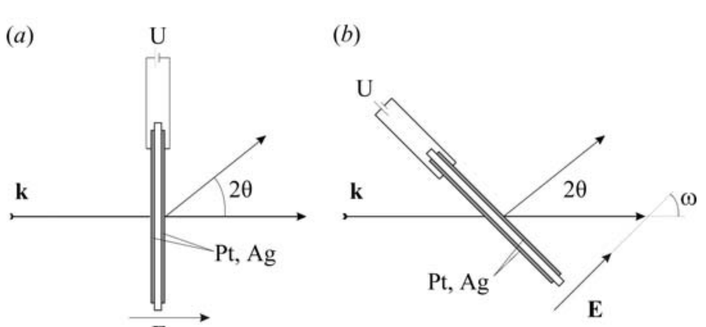

Figure 2.8.4
In situ transmission geometry developed by Schönau, Schmitt *et al.* (2007) with the electric field vector perpendicular to the flat-plate sample surface. The electric field results from an applied voltage U between two opposing sputtered electrodes (Ag, Pt) with a thickness of about 15 nm. (*a*) $\omega = 0°$ and (*b*) $\omega = 45°$.

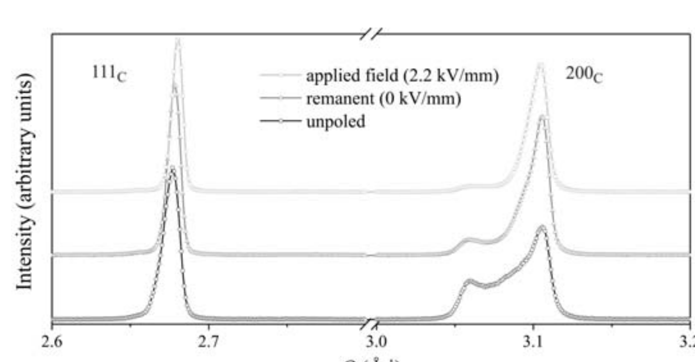

Figure 2.8.5
111_C and 200_C reflections of the unpoled, remanent and applied field state of PIC 151 at $\omega = 0°$. Owing to the piezoelectric effect, the 111_C reflection is shifted. The preferred orientation of the 200_C reflection indicates tetragonal 90° domain switching.