# Role of Buffer Layer in PZT Film-Based Transparent Stack Deposited on Glass

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Chemical-solution-deposition derived piezoelectric thin films integrated with silicon technologies for micro-electromechanical systems (MEMS) have reached the industrial maturity. However, innovative applications, such as acoustic transducers and haptic actuators, require excellent electromechanical properties to be accompanied by an optical transparency in the visible spectrum, which is increasing the need for processing of piezoelectrics on non-silicon substrates. Fused silica is often used in the semiconducting industry due to its optical and thermal properties and is an interesting candidate for the transparent applications.

Layers between substrate and films have an imperative role in the processing of the solution-derived thin films. They can have different functions, including chemical barriers, bottom electrodes, buffers for stress relaxation, seeds for nucleation, etc. The lack of any crystallographic relation and the large mismatch between the coefficients of thermal expansion between amorphous fused silica (0.5 x $10^{-6}$ $K^{-1}$) and PZT (~9 x $10^{-6}$ $K^{-1}$ at processing T) imply necessity for a buffer layer.

We have deposited on fused silica substrates several dielectric and transparent buffer layers, such as $TiO_x$, ZnO, and $Al_2O_3$, with thicknesses between 5 and 30 nm. The PZT solutions, with near-morphotropic-phase-boundary (MPB) composition, were prepared via a 2-methoxyethanol route. After their deposition by spin coating the films were dried, pyrolyzed at 350 °C and heated in a box furnace at 700 °C. The procedure of deposition, drying and pyrolysis was repeated several times to achieve the final thicknesses of ~200 nm. To obtain functional piezoelectric actuators, transparent interdigital electrodes were patterned by photolithography.

The PZT films deposited directly on fused silica are cracked and at least 10 nm thick buffer layer is necessary to obtain homogeneous films. The buffer layer has a strong influence on the orientation of the perovskite phase. For instance, PZT on $TiO_x$ is randomly oriented, while strong (001) orientation is observed on other buffer layers. As shown in Figure 1a, the transmittance in the visible range remains above 60 % after processing. The polarization-voltage loops of fully transparent PZT interdigital capacitors (5-µm gap) on $TiO_x$ buffer layer revealed a coercive voltage and remanent polarization of 27 V and 16 µC/cm², respectively (Figure 1b). In the contribution we will present in detail the impact of the buffer type on the characteristics of these PZT thin films.

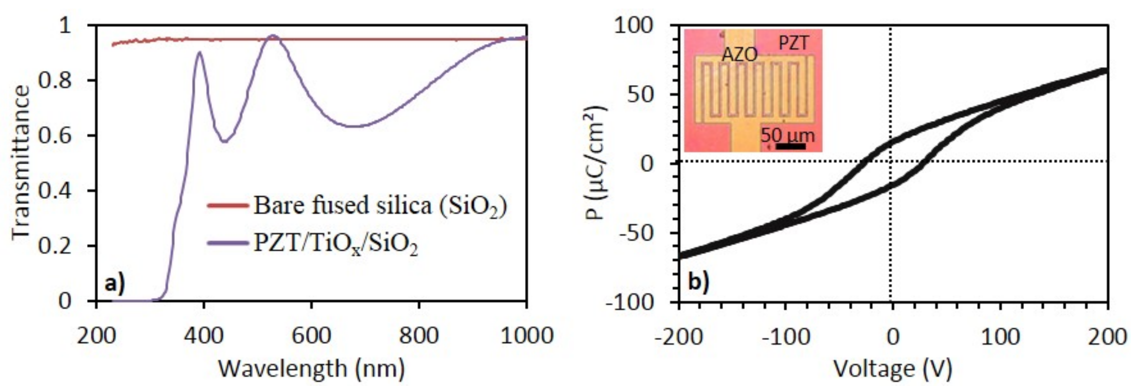


Figure 1: The 200-nm-thick PZT thin film deposited on fused silica substrate with 20-nm-thick $TiO_x$ buffer layer. a) Optical transmittance in visible range. The oscillations are induced by Fabry-Pérot interferences. b) Ferroelectric loop of an interdigital capacitor with Al-ZnO electrodes (5-µm gap).