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Chemically Homogeneous Complex Oxide Thin Films via Substrate Engineering

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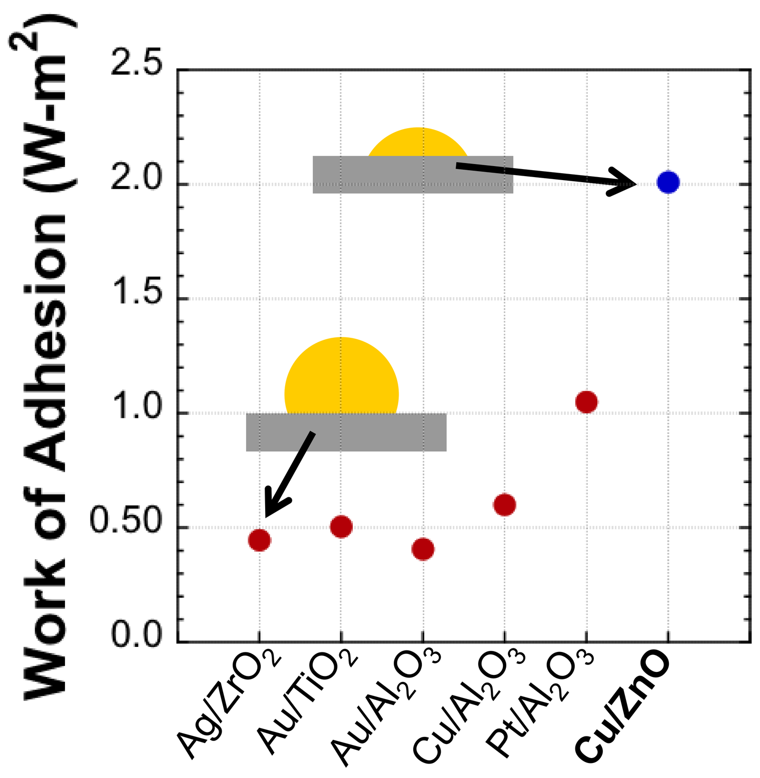
Motivation

Silicon substrates are by far the most commonly used for the deposition of ferroelectric thin films. Despite decades of research, significant limitations exist in metallization technology.

- Pt most common metallization
- Typically adhered to Si via Ti or TiO_x
- Unable to be processed above ~750°C

New Strategy

Utilize Work of Adhesion of metals with oxides to select optimal adhesion material



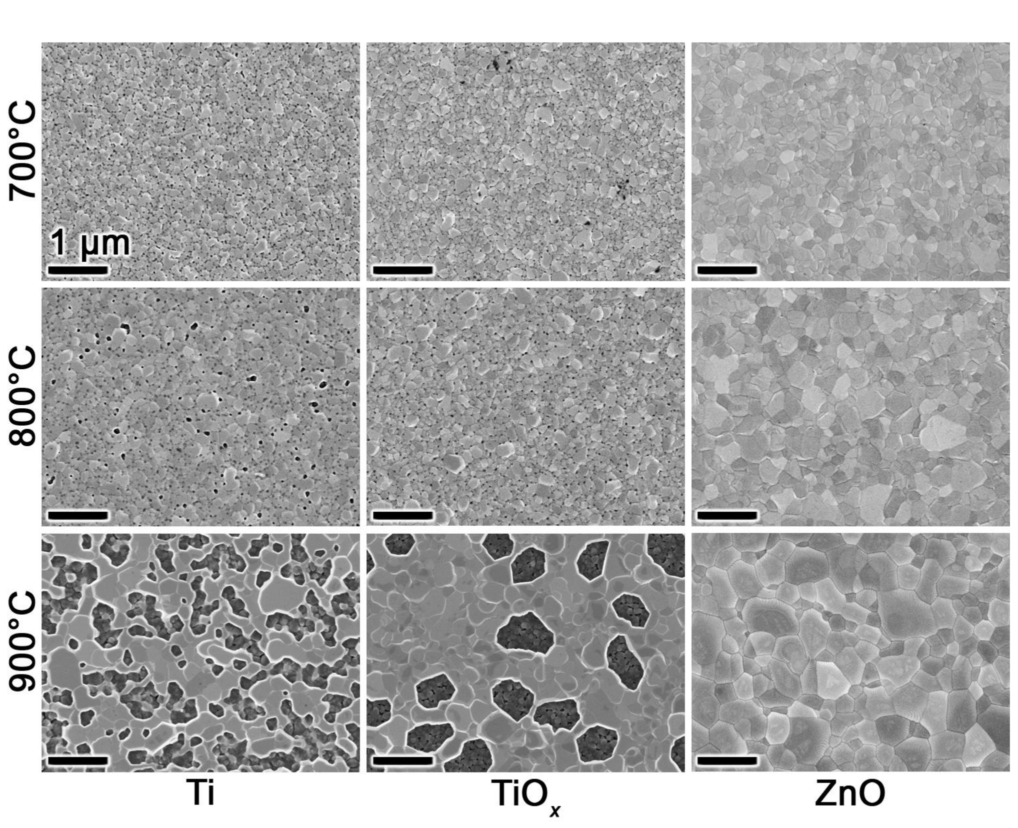
Cu and Pt have similar surface tensions and structure; we may expect similar improvement

Sample Preparation

- 100 nm Pt/40 nm buffer/40 nm SiO_2/Si
- Ti, TiO_x, ZnO, and Pt prepared via RF magnetron sputtering
  - Ti: Ar atmosphere
  - TiO_x: Ar sputter, O_2 anneal
  - ZnO: 1:1 Ar:O_2 atmosphere
  - Pt: Ar Atmosphere
- PZT: Inverted mixing order CSD chemistry
  - 350°C pyrolysis and 700°C crystallization
- $BaTiO_3$: Chelate chemistry
  - 250°C pyrolysis and 900° crystallization

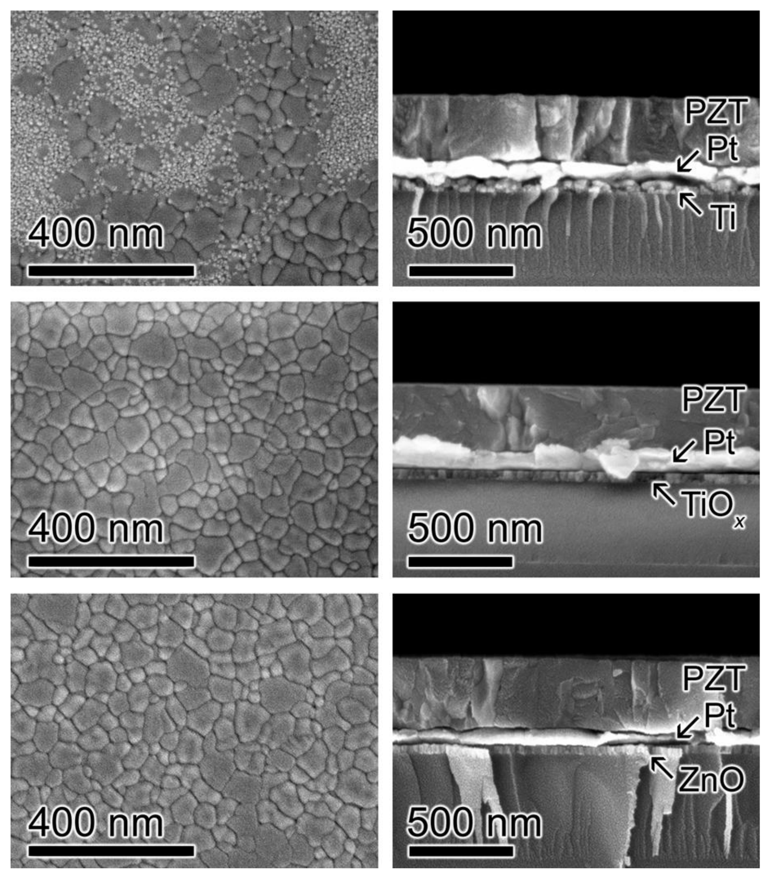
Testing Platinum Stability

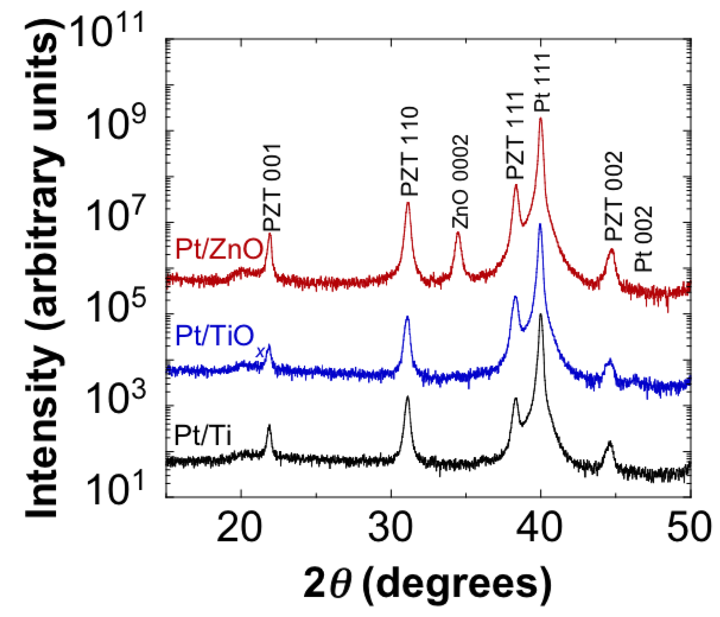
Pt/Buffer/SiO_2/Si samples fired in air for 1 hour and compared



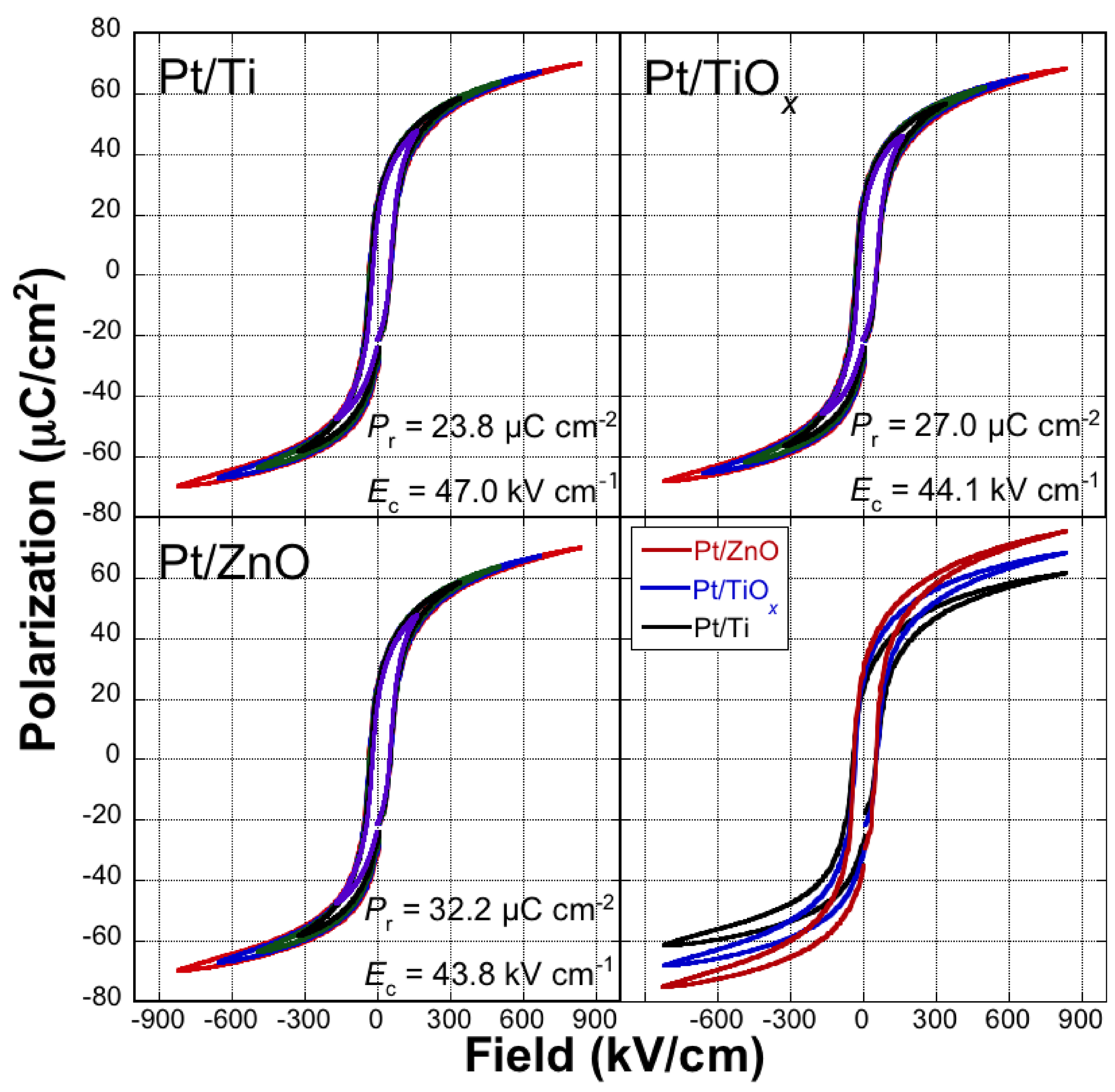
Pt/ZnO stable to much higher temperatures

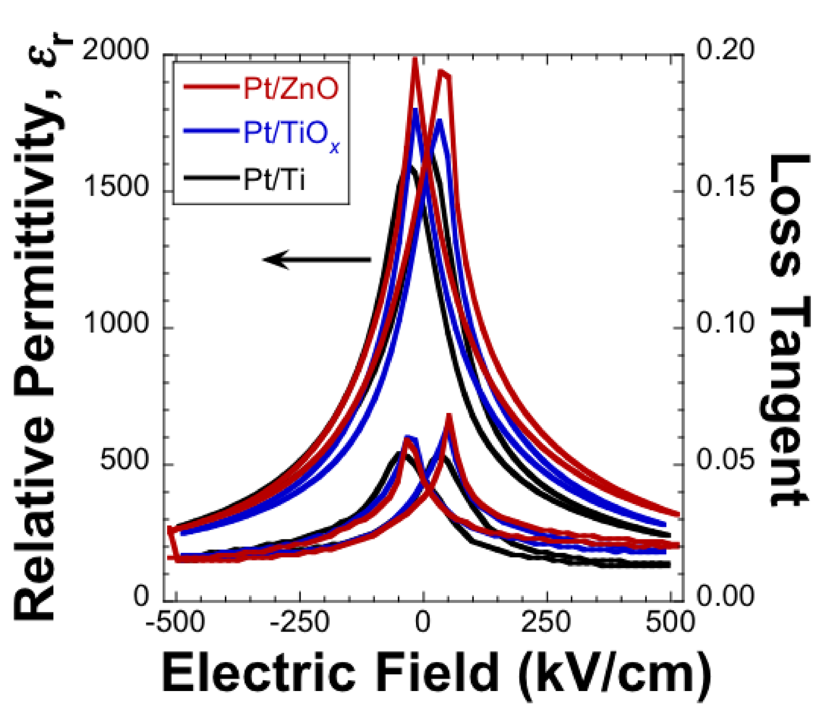
$PbZr_{0.52}Ti_{0.48}O_3$ Thin Films





Microstructure, phase assemblage, and texture nearly identical for PZT films on each substrate

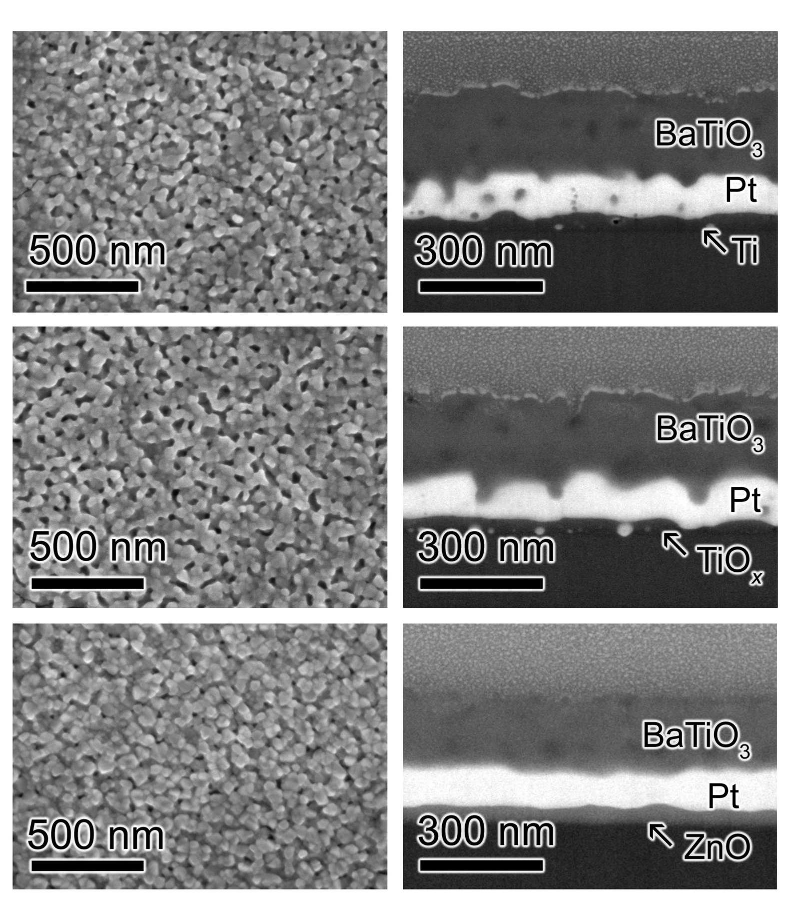


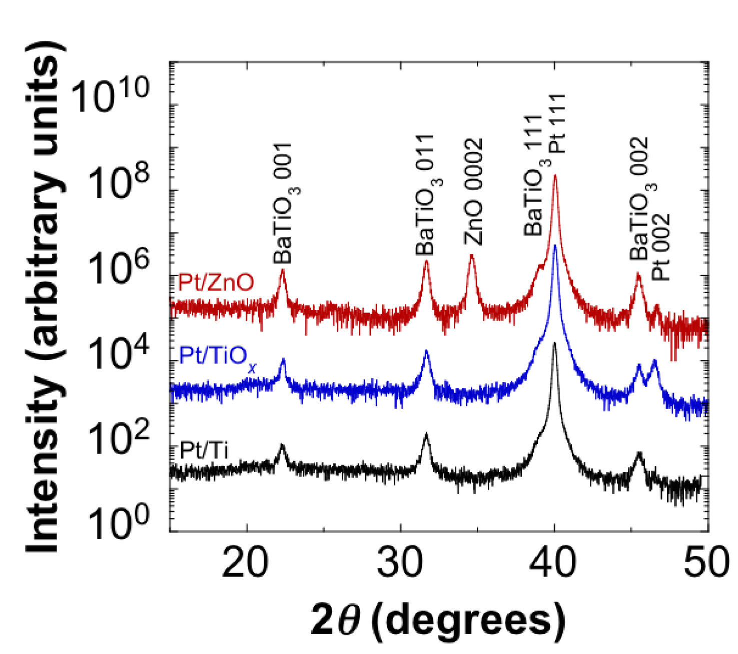


Clear performance differences for PZT on Pt/ZnO versus traditional substrates

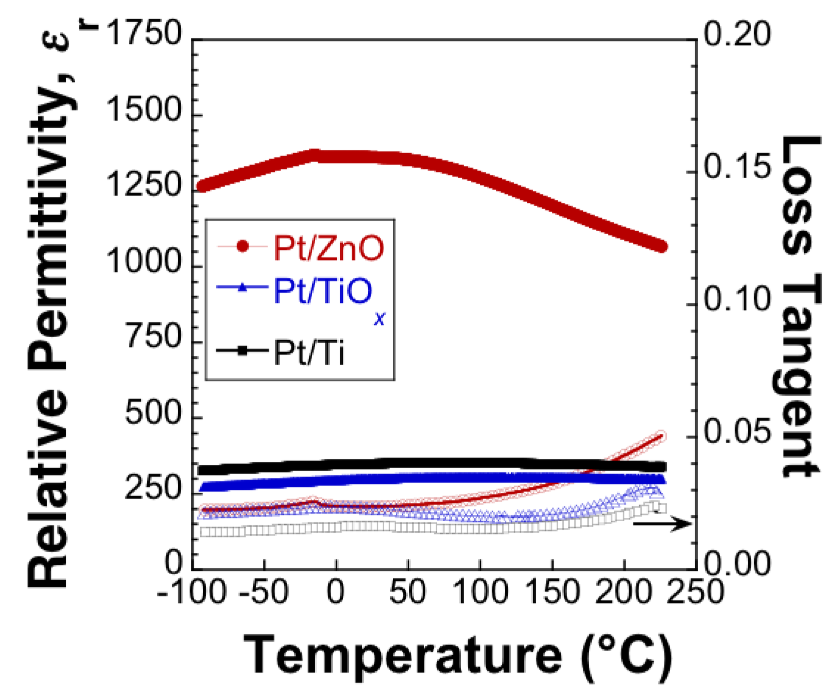
- Increased P_r
- Increased ε_r
- Decreased E_c

$BaTiO_3$ Thin Films



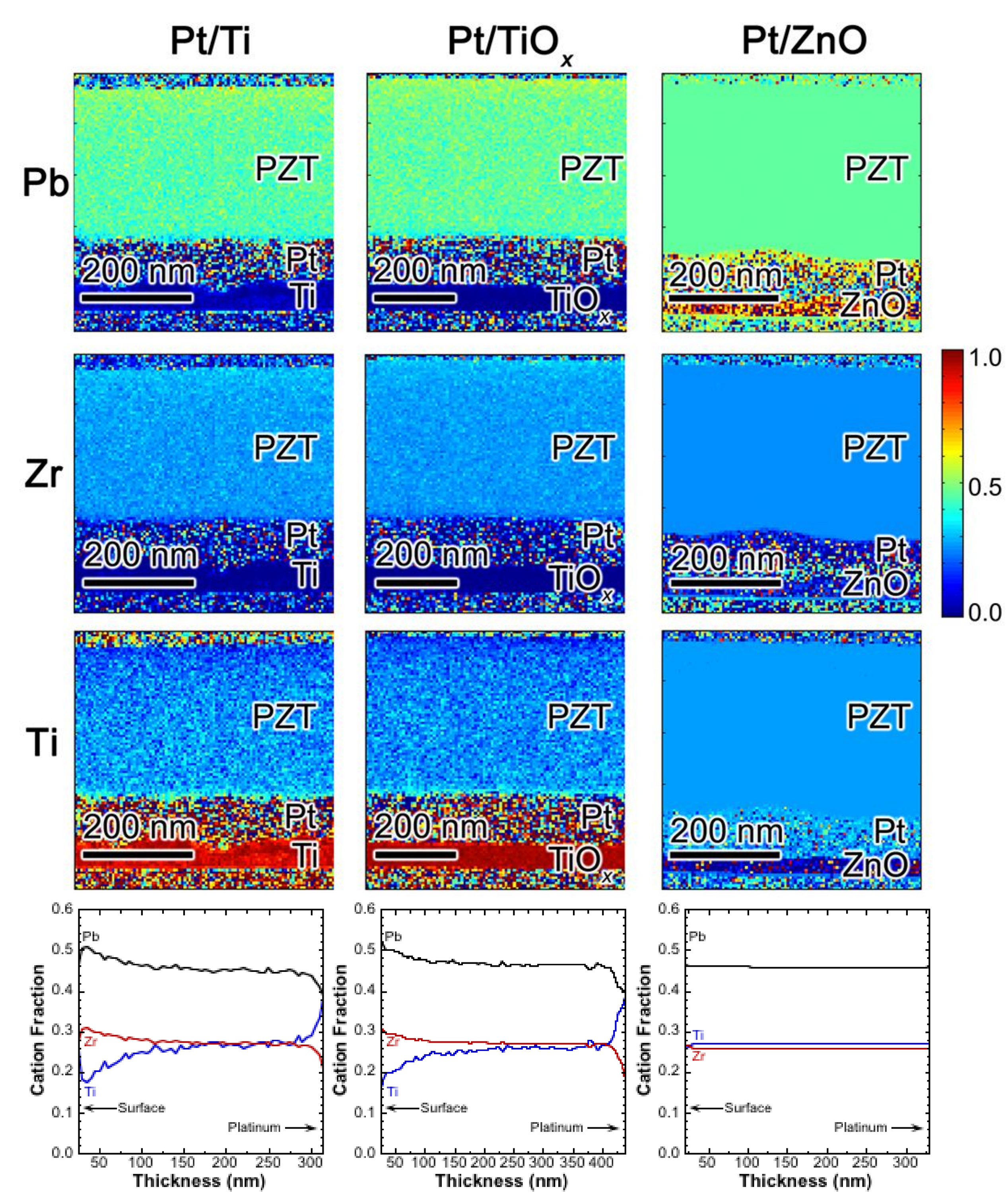


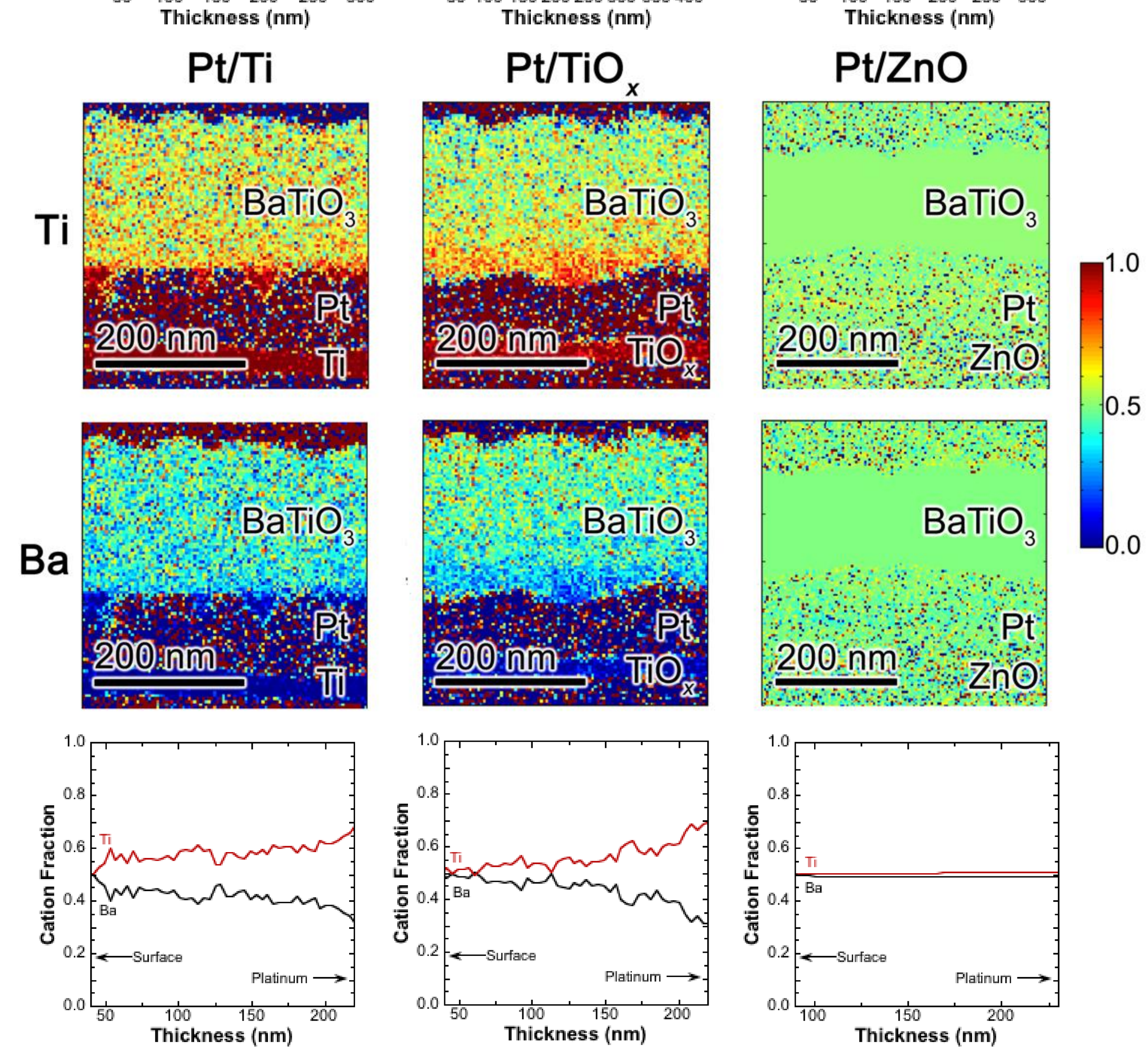
Microstructure, phase assemblage, and texture nearly identical for $BaTiO_3$ films on each substrate



Nearly 400% increase in permittivity for $BaTiO_3$ films on ZnO-buffered platinized silicon substrates

Chemical Analysis: STEM-EDS





Conclusions

- Dramatic improvements in chemical homogeneity with ZnO-buffered substrates
- Concomitant with improved ferroelectric and dielectric responses
- Extrinsic titanium from adhesion layers appears to seed chemical inhomogeneities in traditional substrates

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