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Solution Chemistry, Substrate, and Processing Effects on the Chemical Heterogeneity in PZT Films

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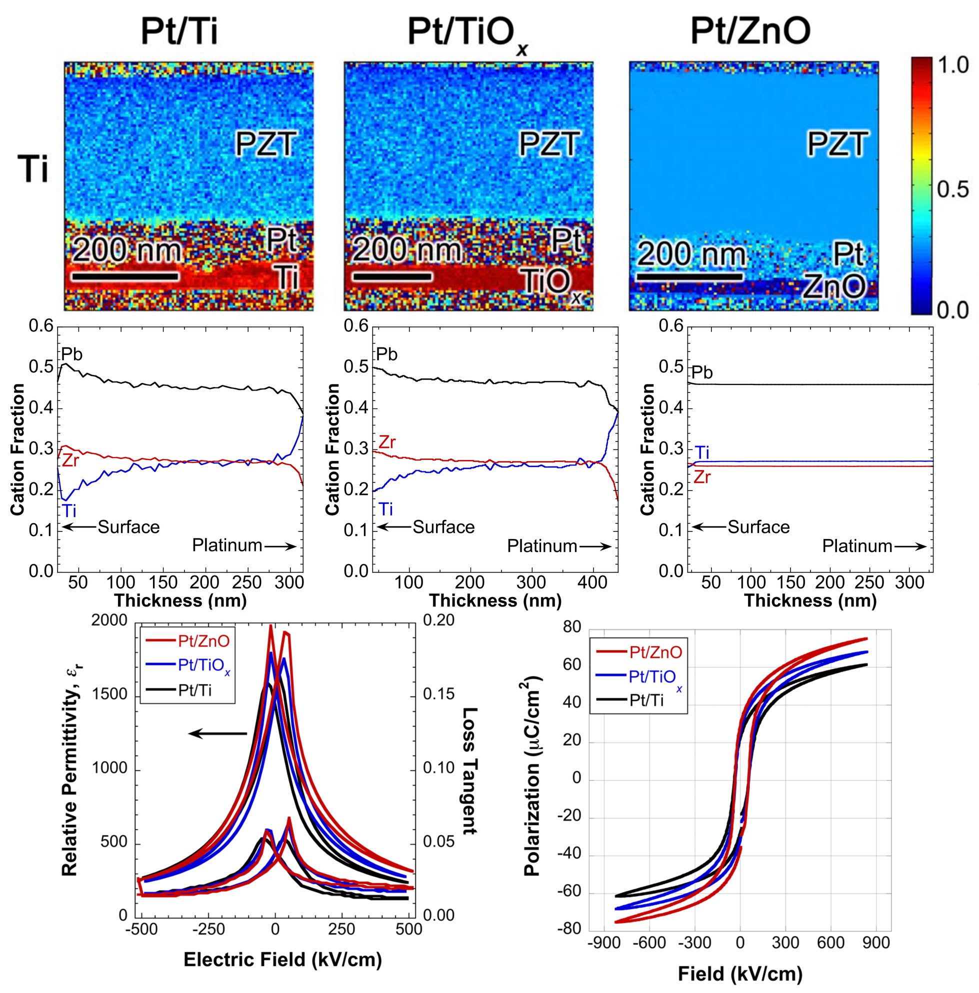
Motivation

Chemical heterogeneities in ferroelectrics have long been identified as a source of degraded ferroelectric, dielectric, and piezoelectric properties. This is particularly true for thin films where substrate sources of contamination can have substantially deleterious effects.

We previously identified a platinized silicon substrate stack, Pt/ZnO/SiO_2/Si, that enables processing at temperatures of 900°C and eliminates diffusion of chemical species from the metallization adhesion layers. Our results indicated that chemical gradients do not form in solution derived PZT films without titanium in the metallization stack. This result is at odds with the many literature reports of chemical gradients in other PZT processing sequences.



Goals

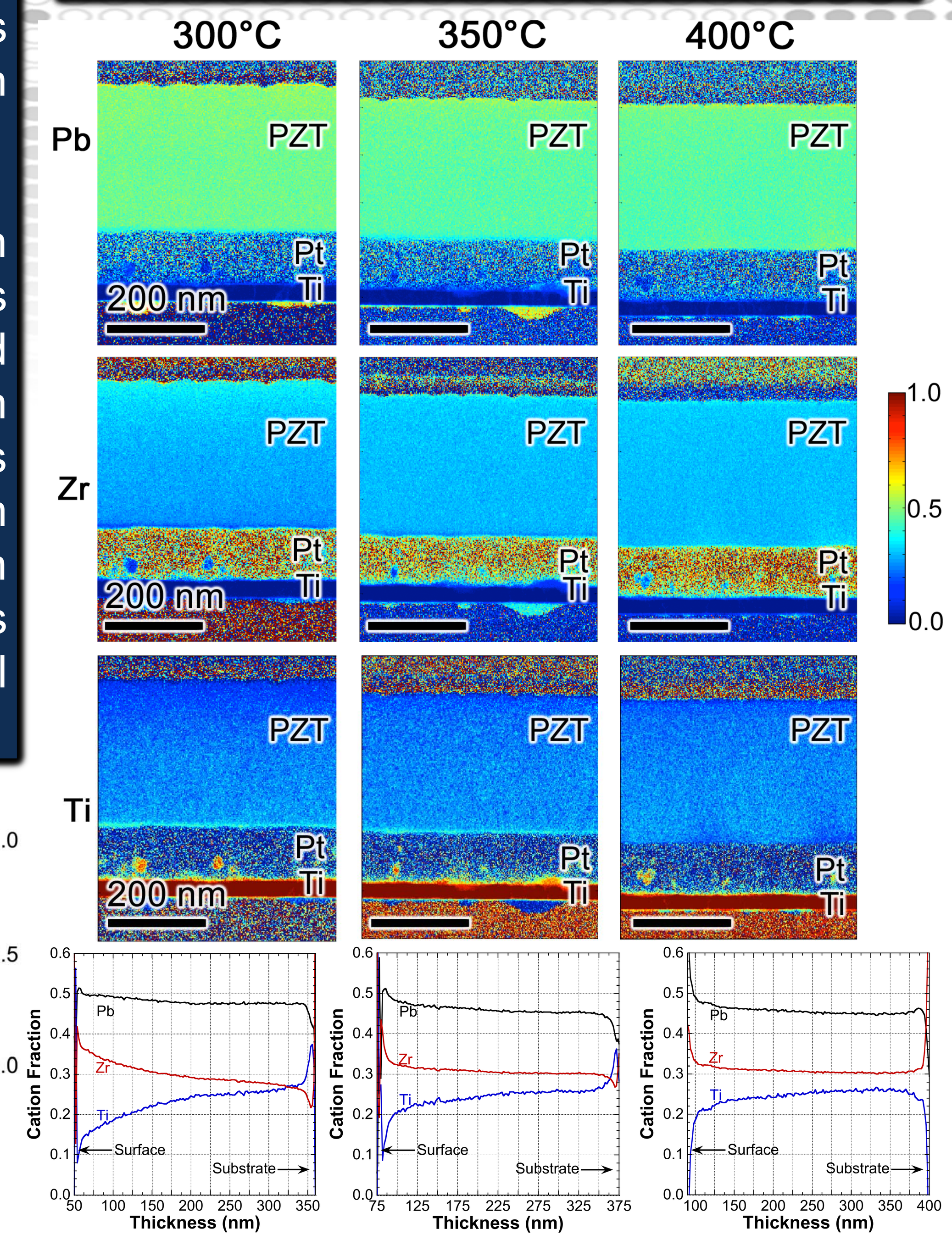
1. Determine if solution chemistry or pyrolysis condition have a role in gradient formation by comparing IMO and 2-MOE chemistries
2. Determine if the heating method and rate affects gradient formation on substrates devoid of titanium
3. Determine if there is a thermodynamic driving force for gradient formation

Methodology

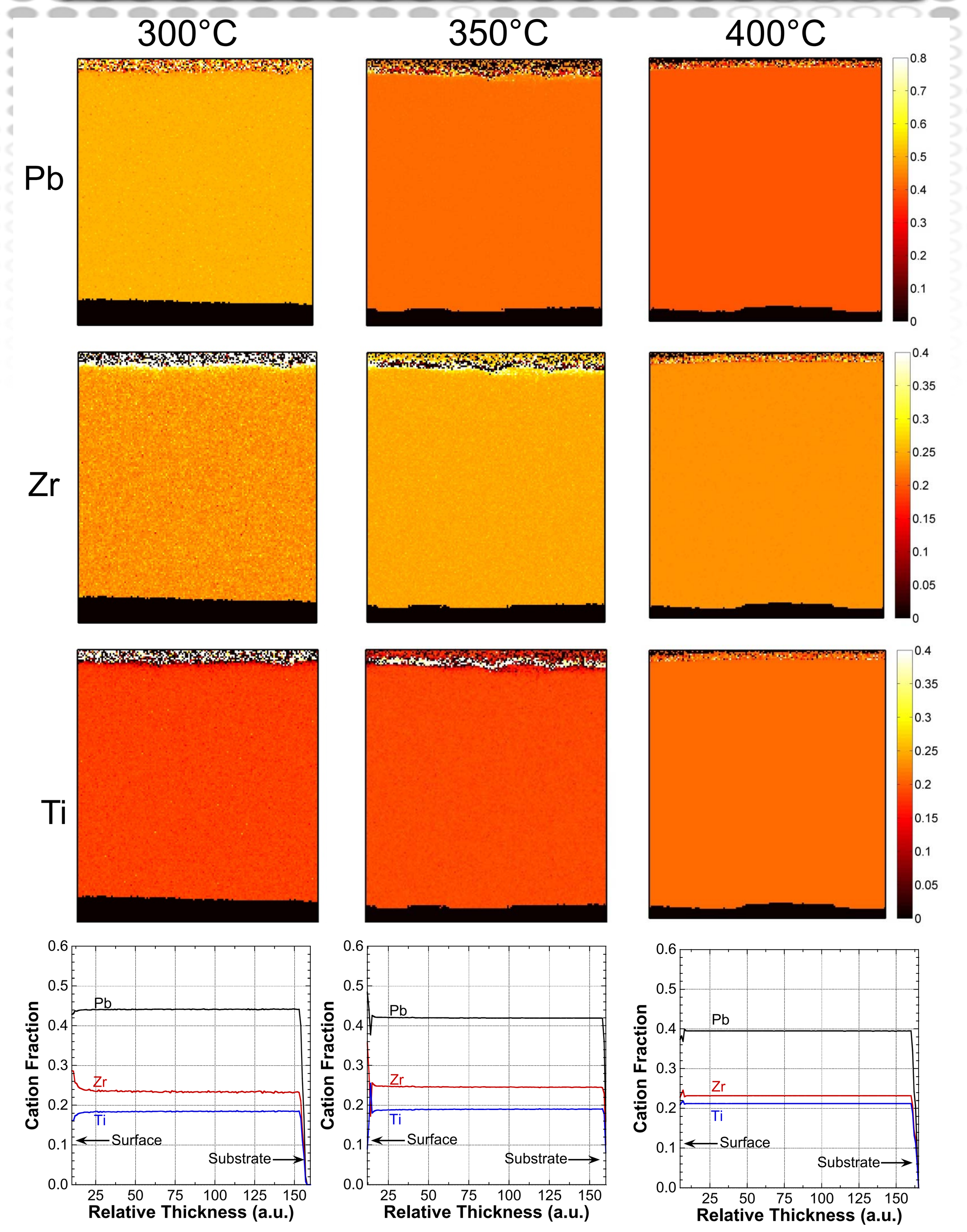
1. Compare IMO and 2-MOE-derived PZT on Pt/Ti and Pt/ZnO
2. Determine pyrolysis temperature effect: 300, 350, 400°C
3. Determine if the heating method and rate affects gradient formation on Pt/ZnO substrates: RTA vs Furnace

Solution Chemistry and Pyrolysis Temperature Effects

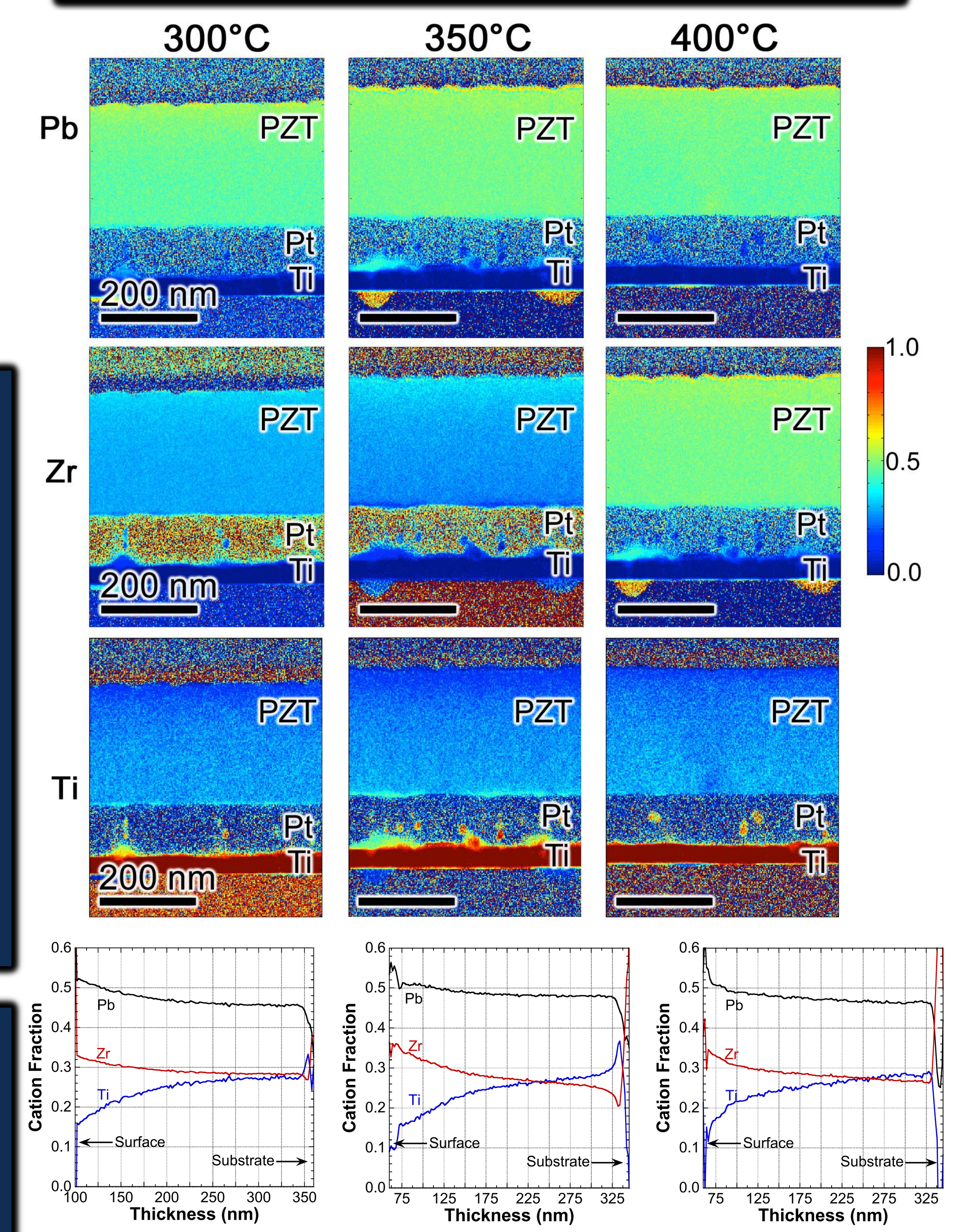
IMO on Pt/Ti/SiO_2/Si



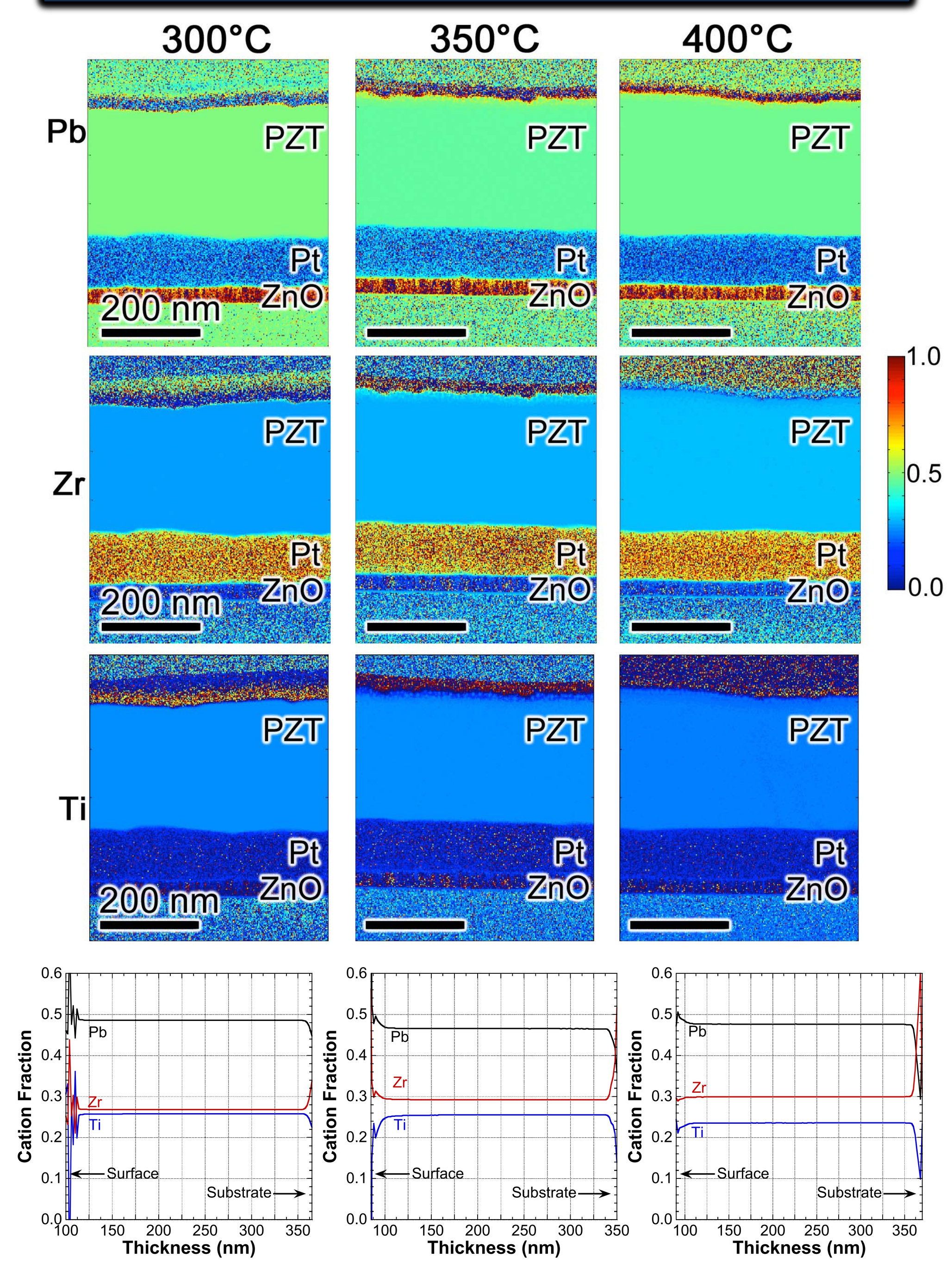
IMO on Pt/ZnO/SiO_2/Si



2-MOE on Pt/Ti/SiO_2/Si



2-MOE on Pt/ZnO/SiO_2/Si

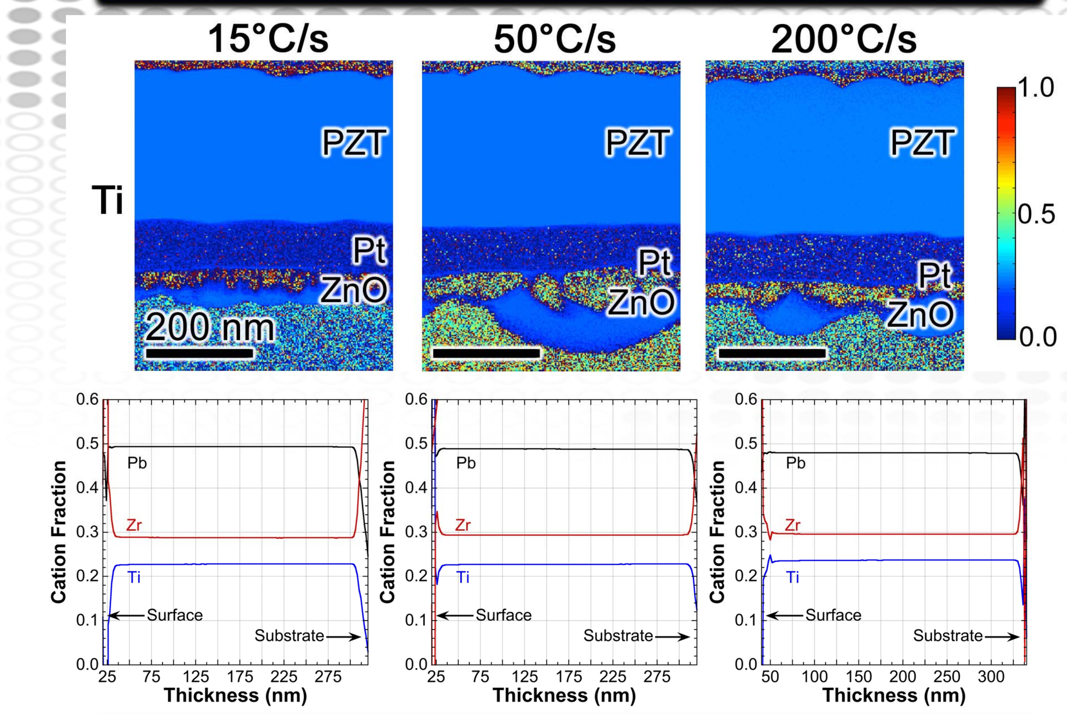


Chemistry and Pyrolysis Results

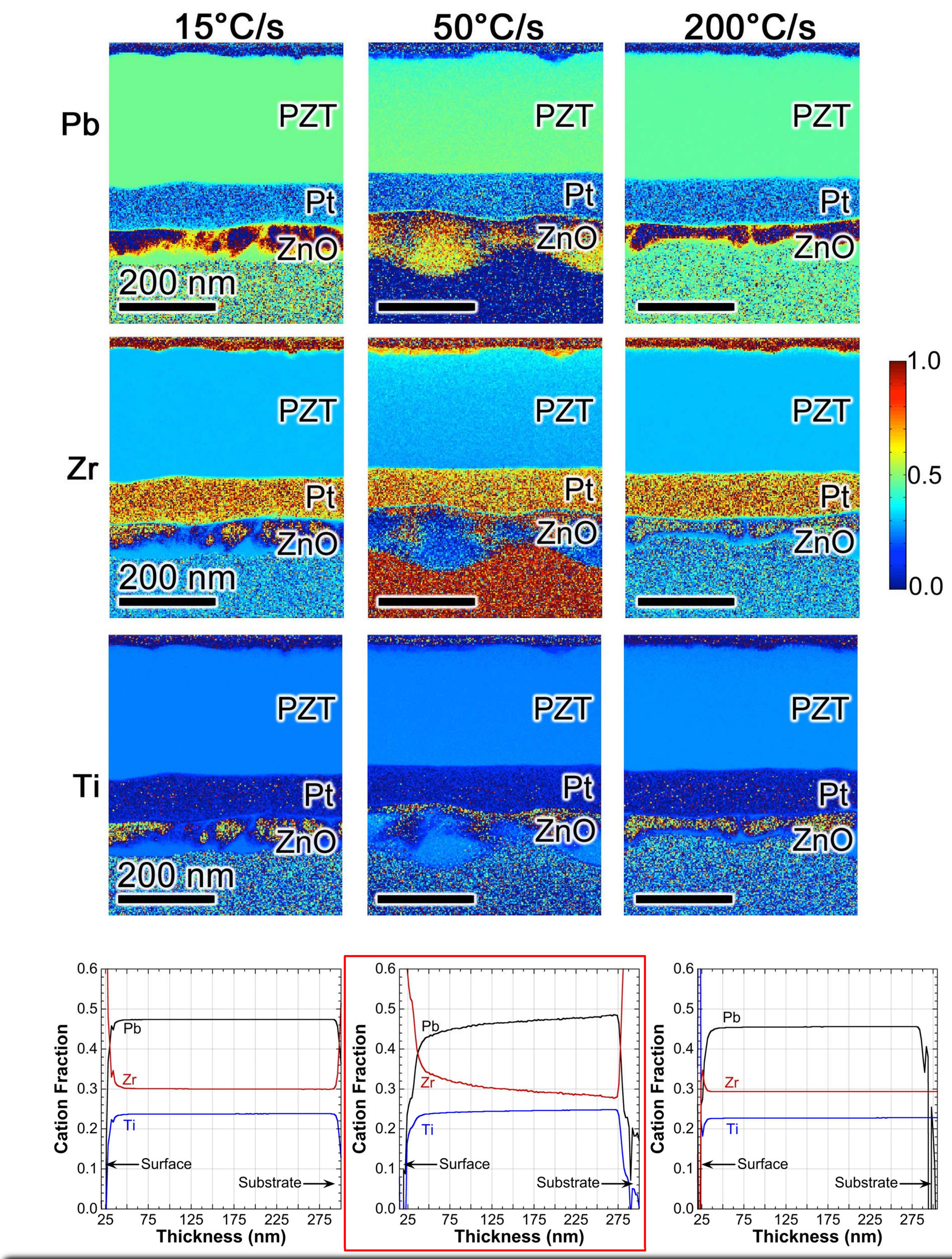
1. Gradients always form when Pt/Ti/SiO_2/Si is used as a substrate
2. Gradients are ***not*** observed when Pt/ZnO/SiO_2/Si is used as a substrate
3. There is no difference with furnace heating between IMO and 2-MOE derived solutions with respect to gradient formation

Heating Rate Effects: RTA

IMO on Pt/ZnO/SiO_2/Si RTA



2-MOE on Pt/ZnO/SiO_2/Si RTA



Heating Rate Results

1. No gradient is observed for different heating rates with IMO solution chemistry
2. Gradient is observed for 50°C/s ramp rate with 2-MOE solution on Pt/ZnO substrate
3. Reaction occurs between ZnO and SiO_2 in RTA anneals – platinum is getting substantially hotter in RTA versus furnace owing to IR absorption

Conclusions

A thermodynamic driving force for preferential $PbTiO_3$ nucleation is not supported by these results. The gradient formation appears to be driven by extrinsic chemistry and processing effects.

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