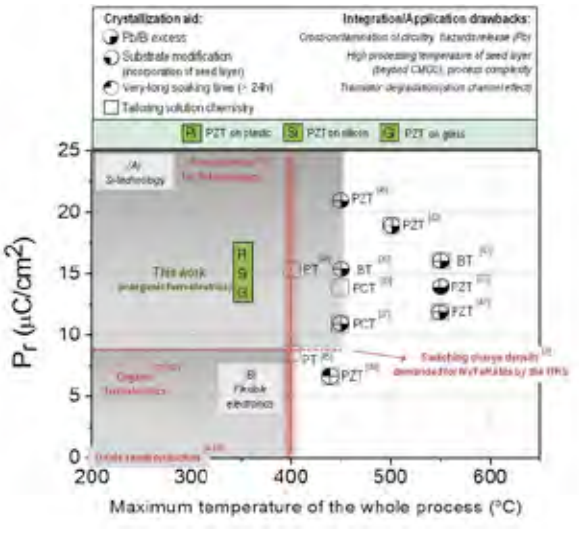
Activated Solutions Enabling Low-Temperature Processing of Functional Ferroelectric Oxides for Flexible Electronics

Iñigo Bretos[1], Ricardo Jiménez[1], Aiying Wu[2], Angus I. Kingon[3], Paula M. Vilarinho[2], M. Lourdes Calzada[1]

In the case of the most widely used inorganic materials in electronics, i.e. semiconductors, significant efforts are being devoted to their low-temperature fabrication for successful integration with flexible electronics. But now the need for direct integration of other active layers on polymers is mandatory to increase functionality of flexible devices. This is a major opportunity for ferroelectrics, since their intrinsic multifunctionality will allow diverse operations as memories, sensors, actuators, transducers making real applications not possible before (e.g. smart skin, flexible sensitive displays, photovoltaic cells, eye-type imagers). But, inorganic ferroelectrics require high temperatures to crystallise that exceeds by far the thermal stability of plastics.

With a unique technology we proved the concept for a solution method that enables the processing of functional oxides at temperatures that direct-large-area integration of active layers with flexible electronics is turned into reality. We demonstrate the concept on the most important multifunctional oxide, lead-zirconate-titanate. Low temperature limit of crystallization of 300ºC, using a strategy that combines seeded diphasic precursors and photochemical solution deposition was reached. Based on the synergy of this strategy it is possible to overcome problems traditionally associated with low-temperature fabrication of ferroelectric oxide films, in particular absence of ferroelectric response, thereby allowing the use of these multifunctional layers in emerging electronics, as advanced devices supported on flexible polymeric substrates. We proved that properties of these ferroelectric layers on flexible plastic fulfill the major requirements demanded for devices, showing a wider temperature range of applicability and functionality than those of high-K dielectrics or organic ferroelectrics. This is a platform that can be used for many other functional oxide layers.



1 — Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC), Spain
2 — Department of Materials and Ceramics Engineering & CICECO, University of Aveiro
3 — School of Engineering, Brown University, Providence, USA

FIGURE 1
Key relevant challenges for the integration of ferroelectric oxide films with the Si-technology and flexible electronics.

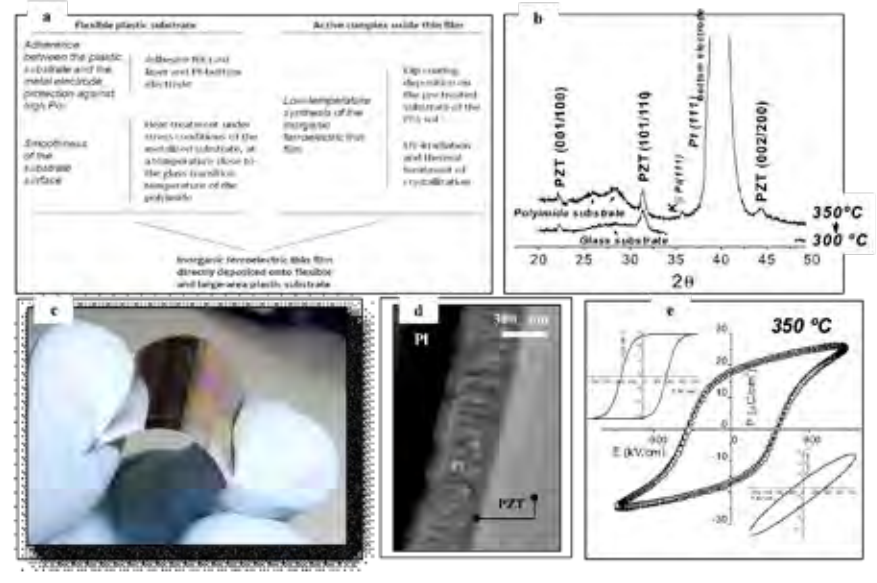


FIGURE 2
Main features of the low-temperature solution processed inorganic PZT [Pb(Zr0.30Ti0.70) O3] ferroelectric layers on flexible plastic substrates.