Chemical Solution Deposition of Piezo Films for Prototype Microelectromechanical Systems (MEMS)

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Chemical solution deposition (CDS) enables excellent density and electrical properties for oxide films with complex chemistries, including piezoelectrics. Penn State University uses CSD for prototyping MEMS with $PbZr_{1-x}Ti_xO_3$ (PZT) and $(1-x)PbMg_{1/3}Nb_{2/3}O_3$-$xPbTiO_3$ (PMN-PT). Chemical solution deposition, however, has many challenges that must be overcome to achieve reproducibly robust properties.

This work will address some of the many challenges associated with sol-gel processing on 4-inch, 6-inch and 8-inch wafers in a university laboratory setting.

Maintaining the uniformity of sol-gel deposited films and substrate temperature during pyrolysis becomes progressively more problematic as wafer size increases. During the synthesis of films with random orientation,
this non-uniformity can lead to irregular grain size, secondary phase formation (e.g. pyrochlore PZT) and/or increased porosity, all of which can be detrimental for thin film electrical properties.

Additionally, the process variability becomes especially significant during the preparation of films when a preferred crystallographic orientation is desired. Temperature non-uniformity, which increases with wafer size, can greatly reduce the preferred orientation and is critical not just for crystallization but at each of the pyrolysis steps in the fabrication process.

One of the factors that complicates temperature uniformity are the stresses that develop as each successive film layer is applied. This can result in cambering of the substrate during temperature cycles and hillocking within the underlying electrode.

When these processes are controlled, high quality piezoelectric films can be deposited. This paper will describe the deposition conditions, as well as the integration of the films into a variety of PiezoMEMS devices.