

Pushing the Performance of Electro-Mechanical Thin Films

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We are witnessing the advent of the 4th industrial revolution, and are heading towards a largely robotized world. A lot of analogue electro-mechanical devices for sensing, actuation, communication, and fabrication are necessary ingredients for such revolution. Piezoelectricity plays an important role in any electro-mechanical conversion, and is used for instance in ultrasonic imaging and mobile phone communication. The necessary drive for miniaturization will result in a strong demand for piezoelectric thin films, with improved, optimized properties. The talk will first introduce basic phenomena of electro-mechanical coupling: electrostriction, piezoelectricity, and its relation to ferroelectricity. The most important thin film piezoelectric materials are presented. Challenges and achievements in growth, integration, and properties will be reviewed. Results on performance issues such as achievable piezoelectric stress will be discussed for lead-zirconate-titane (PZT) thin films. One of the major deposition methods for PZT is the sol-gel route, in which metal alkoxide solutions are spun on, pyrolysed and crystallized in multiple steps. One of the issues in this process is the formation of a compositional gradient, because the formation of Ti rich perovskite is thermodynamically more favorable than Zr rich compositions, and because of the large mobility of the cations during the crystallization process in the non-crystallized, amorphous phase. While PZT thin films are good for micro actuators, aluminum nitride thin films are superior at GHz frequency applications because of a higher mechanical quality factor and stability. A recent discovery by Akiyama and coworkers showed that alloying with scandium nitride leads to much larger piezoelectric coefficients. Most recent results on AlScN properties evaluated in our own study confirm the large increase, not only in the longitudinal, but also in the transverse response and the piezoelectric coupling. Results will be compared with ab-initio calculations. The talk will finish with an outlook on remaining challenges, and potential applications.

