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, aging and imprint will be discussed for lead-zirconate-titante (PZT) thin films. While these are good for micro actuators, aluminum nitride is superior at GHz frequency applications because of its higher mechanical quality factor. A recent discovery shows that alloying with scandium nitride leads to much larger piezoelectric coefficients. Most recent results on AlScN properties will be compared with ab-initio calculations. The talk will finish with an outlook on remaining challenges, and potential applications.