Atomic layer deposition of nano-functional metal-oxides studied in-situ
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Atomic layer deposition (ALD) is a powerful method for depositing ultra-thin oxides with well-defined and controlled chemical-physical properties. One of the main properties of ALD is the homogeneous growth on large area substrates, like amorphous or nano-structured (nano-tubes, nano-pillars, nano-dots) materials. The growth can be regulated in the sub-monolayer regime and delivers oxides with controllable stoichiometry and density. We developed an in-situ ALD-chamber for studying the initial growth of various metal-oxides (Al₂O₃, HfO₂, ZrO₂) on Si and GaAs and to modify their properties at the atomic level by varying the ALD parameters. The growth properties were determined by synchrotron radiation-based photoemission and absorption spectroscopy (XPS and XAS) measured on the U49-2/PGM2 beamline at BESSY-II, Berlin, by electron energy loss spectroscopy (EELS) and by atomic force microscopy (AFM). We found that the ultra-thin oxides grown by ALD reach their bulk electronic properties already in the monolayer regime, while their morphology strictly follows that of the substrate at the Ångstrom level. From our research we conclude that the potential applications of ALD in many technologically important fields can be still extended by the in-situ characterization as it gives the possibility to modify the growth properties for increasing the nano-functionality of the oxide structures.