Reactive Sputter Deposition for Functional Thin Films: From Photocatalysis to Bio-inspired Electronic Devices

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ABSTRACT

Metal oxide thin films, in particular those made of semiconducting transition metal oxides, are interesting for a broad range of applications, ranging from photocatalysis, over sensors for the detection of photons or gas molecules to memristive switching. In memristive devices, metal oxide thin films are broadly applied as matrix for either oxygen vacancy migration or metal cation migration, that are crucially impacting the formation of conductive filaments. Thus, thin film morphology, crystallinity and stoichiometry are decisive for the functional properties. Reactive sputter deposition offers the possibility to prepare metal oxide thin films with a broad range of properties, allowing to tailor the thin film device to fulfil specific functional requirements. Insulating and semiconducting metal oxide thin films are prepared by unipolar pulsed DC magnetron sputtering from a metallic target in the presence of a reactive O_2/Ar atmosphere. This work presents an overview over different functional thin films, including SiO_2, Al_2O_3, NiO, TiO_2 and CuO, for photocatalytic degradation, memristive devices and sensor applications. Special attention is paid to the resulting thin film morphology, as it determines the usability of thin film devices for sensor applications, for memristive devices and for photocatalysis. While for Al_2O_3 and SiO_2 smooth, closed layers are obtained, which makes these materials promising candidates for memristive devices, for NiO, TiO_2 and CuO the thin film morphology is dominated by well-separated, high aspect ratio columns, which are ideal for applications which require a high surface area. Using a pulsed DC reactive sputtering process and a controlled Ar/O_2 ratio in the reactive atmosphere it is possible to obtain tailored thin film morphologies.

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[2] A. Vahl, N. Carstens, T. Strunskus, F. Faupel, A. Hassanien, Diffusive memristive switching on the nanoscale, from individual nanoparticles towards scalable nanocomposite devices, Scientific Reports, 9 (2019) 17367, DOI: 10.1038/s41598-019-53720-2.