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Measurement of thickness and energy input distributions during pulsed laser deposition of oxides

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Pulsed laser deposition (PLD) is a very versatile research tool for the preparation of a wide variety of thin films, especially of oxides [1]. We want to use PLD as a fast and flexible plasma-assisted deposition technique for a high-throughput screening of photoelectrode materials for solar water splitting [2]. Our focus is on the preparation of combinatorial libraries of different metal oxides with 1- or 2-dimensional composition distributions on a substrate with a size of 50x50 mm^2. For this purpose, it is important to know the film thickness profile on the substrate for the ablation from each oxidic target.Therefore, in this work we report on the measurement of the thickness (-rate) distributions from different binary and ternary oxide targets (Bi_2O_3, V_2O_5, Al_2O_3, Nb_2O_5, WO_3, $BiVO_4$, $CuWO_4$ etc.). The PLD system (Prevac, Poland) consists of a large PLD chamber where up to six 1" or 2" targets can be ablated subsequently. The ablation laser is a 0.8 J KrF excimer laser (LPXpro, Coherent), which is focused onto the target under an angle of 45°. The ablated area on the target can be varied from 1 to 10 mm^2, thus allowing energy densities from 0.1 to 10 Jcm^{-2}. The thickness distributions are measured with a quartz crystal monitor (QCM) which is moved over the ablation spot. Typically, during the ablation from an oxidic target oxygen is lost during the passage from the target to the substrate, resulting in oxygen-deficient films for depositions in vacuum. In order to obtain stoichiometric films, an oxygen background has to be added. This can also be used for the thermalization of the energetic particles which are formed in the ablation process. The background gas not only thermalizes but also scatters the ablated atoms and therefore changes the thickness distributions. Additionally, we measure the energy of the ions by a time-of-flight measurement of the ions on the front electrode of the QCM.

[1] M. Lorenz, Pulsed Laser Deposition of ZnO-Based Thin Films, in: K. Ellmer, A. Klein, B. Rech (Eds.) Transparent Conductive Zinc Oxide: Basics and Application in Thin Film Solar Cells, Springer, Berlin, 2008, pp. 55.

[2] L.M. Peter, Electroanal., 27 (2015) 864.

Keywords

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