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Physical and photo-electrochemical characterizations of ZnO thin films deposited by ultrasonic spray method: Application to HCrO4?photoreduction

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Abstract: ZnO thin films, prepared by ultrasonic spray onto glass substrate, crystallize in the wurtzite structure. The XRD pattern shows preferential orientation along the [0 0 2] direction. The films deposited at 350 consist of 60 nm crystallites with an average thickness of ?150 nm and SEM images show rough surface areas. The gap increases with increasing the temperature of the substrate and a value of 3.25 eV obtained for films deposited at 350?C. ZnO is nominally non-stochiometric and exhibits n-type conduction because of the native defects such as oxygen vacancies (VO) and/or interstitial zinc atom (Zni) which act as donor shallows. The conductivity is thermally activated and obeys to an exponential type law with activation energy of 57 meV and an electron mobility of 7 cm2V?1s?1. The capacitance-voltage (C?2measurement in acid electrolyte (pH ? 3) shows a linear behavior with a positive slope, characteristic N-type conduction. A flat band potential of ?0.70 VSCE and a donors density of 5.30 × 1016cm?3are deter-mined. The Nyquist plot exhibits two semicircles attributed to a capacitive behavior with a low density of surface states within the gap region. The centre is localized below the real axis with a depletion angle of 16?ascribed to a constant phase element (CPE) due to the roughness of the film. The energy band diagram assesses the potentiality of ZnO films for the photo-electrochemical conversion. As application, 94% of chromate (3.8 × 10?4M) is reduced after 6 h under sunlight (AM 1) with a quantum yield of 0.06%and the oxidation follows a first order kinetic.

Keywords : ZnO, thin film, Ultrasonic spray, Photo-electrochemical, Chromate, Sunlight