Comparison of DC and RF Sputtering: Effect on Structural and Optical Properties of $ZnSnN_2$

T. N. K. Bui, M. Halbwax, and J. P. Vilcot

Univ. Lille, CNRS, Centrale Lille, Yncréa ISEN, Univ. Polytechnique Hauts-de-France, UMR 8520 - IEMN, F-59000 Lille, France

Keywords: $ZnSnN_2$, Zn-IV-N_2 absorber, magnetron sputtering, PV cell applications.

Thin-film PV technology was initially used as a low raw material consumption, so a low cost, technology. Amorphous Si was firstly used; it effectively led to a low cost technology but also a low efficiency one. CdTe, and more recently copper indium gallium di-selenide (CIGS), materials were then used. Thin-film solar cells are fabricated by using different techniques (PVD, CVD, ECD, plasma-based, hybrid, etc.). Sputtering PVD [1] is one of the methods used for producing, tailoring and engineering of the layers to improve thin-film device performance. Sputtering systems are used in practice including DC diode, RF-diode, magnetron diode, and ion beam sputtering. The main difference between DC and RF sputtering are the source of power and target materials. RF sputtering allows application to a wider range of materials for both conductive and non-conductive materials. Meanwhile, DC is only effective for metals or semiconductors. Several publications have studied the comparison of DC and RF modes. Structural, optical properties and morphologies of alumina [2] and zinc oxide thin films [3] were prepared by DC and RF magnetron sputtering and exhibited different properties. SiCN coatings also shows the change in their structural and mechanical properties [4].

Here, $ZnSnN_2$ thin films are produced on glass substrate by either sputtering a single $Zn_{42.2}Sn_{57.8}$ target or co-sputtering two separate Zn and Sn targets at room temperature, in N_2 mixed Ar (1/3 ratio) environment. The deposition system that is used is an Alliance Concept CT200 sputtering machine with DC and RF generators. Optical and electrical properties obtained in UV-VIS and Hall measurements do not show significant differences when changing DC and RF source for each target. The crystal structures of the $ZnSnN_2$ were analyzed by using X-ray diffraction equipment (Rigaku SMARTLAB) in Bragg-Brentano mode with Cu-Kα radiation. The most stable wurtzite-derived structure of bulk $ZnSnN_2$ was given to be the orthorhombic Pna21 phase, researched in previously reports [5][6][7], the observed peaks are located at 2θ: 30.1°, 32.4°, 34.3°, 45.0°, 53.6°, 59.2°. Even if optical and electrical properties were almost identical, changes in material morphology occur as changing sputtering mode.

References:

[1] S. Swann, "Magnetron sputtering," *Phys. Technol.*, vol. 19, no. 6, pp. 67–75, 1988.

[2] M. Serényi, T. Lohner, G. Sáfrán, and J. Szívós, "Comparison in formation, optical properties and *applicability* of DC magnetron and RF sputtered aluminum oxide films," *Vacuum*, vol. 128, pp. 213–218, 2016.

[3] A. Mosbah *et al.*, "Comparison of the structural and optical properties of zinc oxide thin films deposited by d.c. and r.f. sputtering and spray pyrolysis," *Surf. Coatings Technol.*, vol. 200, no. 1-4 SPEC. ISS., pp. 293–296, 2005.

[4] H. Hoche, C. Pusch, R. Riedel, C. Fasel, and A. Klein, "Properties of SiCN coatings for high temperature applications - Comparison of RF-, DC- and HPPMS-sputtering," *Surf. Coatings Technol.*, vol. 205, no. SUPPL. 1, pp. S21–S27, 2010.

[5] L. Lahourcade, N. C. Coronel, K. T. Delaney, S. K. Shukla, N. A. Spaldin, and H. A. Atwater, "Structural and optoelectronic characterization of RF sputtered ZnSnN 2," *Adv. Mater.*, vol. 25, no. 18, pp. 2562–2566, 2013.

[6] P. C. Quayle, K. He, J. Shan, and K. Kash, "Synthesis, lattice structure, and band gap of ZnSnN2," *MRS Commun.*, vol. 3, no. 3, pp. 135–138, 2013.

[7] N. Coronel and L. Lahourcade, "US 2013/0240026 A1 Photovoltaic semiconductive materials," 2013.