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| **Judul Artikel** | : | Characterization of $SnO_2$ Film with Al-Zn Doping Using Sol-Gel Dip Coating Techniques |
| **Penulis** | : | Aris Doyan, Susilawati, Norma Ikraman and Muhammad Taufik |
| **Nama Seminar/Konferensi/Simposium** | : | Journal of Physics: Conference Series |
| **Penyelenggara/Penerbit** | : | IOP Publishing Ltd |
| **Waktu/Tempat Pelaksanaan** | : | 6-7 September 2017/Yogyakarta, Indonesia |
| **Halaman** | : | 012015-1 -012015-6 |
| **ISBN/ISSN** | : | *ISSN: 1742-6596* |
| **Web Prosiding** | : | https://iopscience.iop.org/issue/1742-6596/1011/1 |
| **URL Dokumen** | : | https://iopscience.iop.org/article/10.1088/1742-6596/1011/1/012015/pdf |
| **DOI** | : | http://doi.org/10.1088/1742-6596/1011/1/012015 |
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| **Tanggal/Waktu** | : | Semester Gasal 2017/2018 |
| **Satuan** | : | 1 Makalah/tahun |
| **Volume Kegiatan** | : | 1 |

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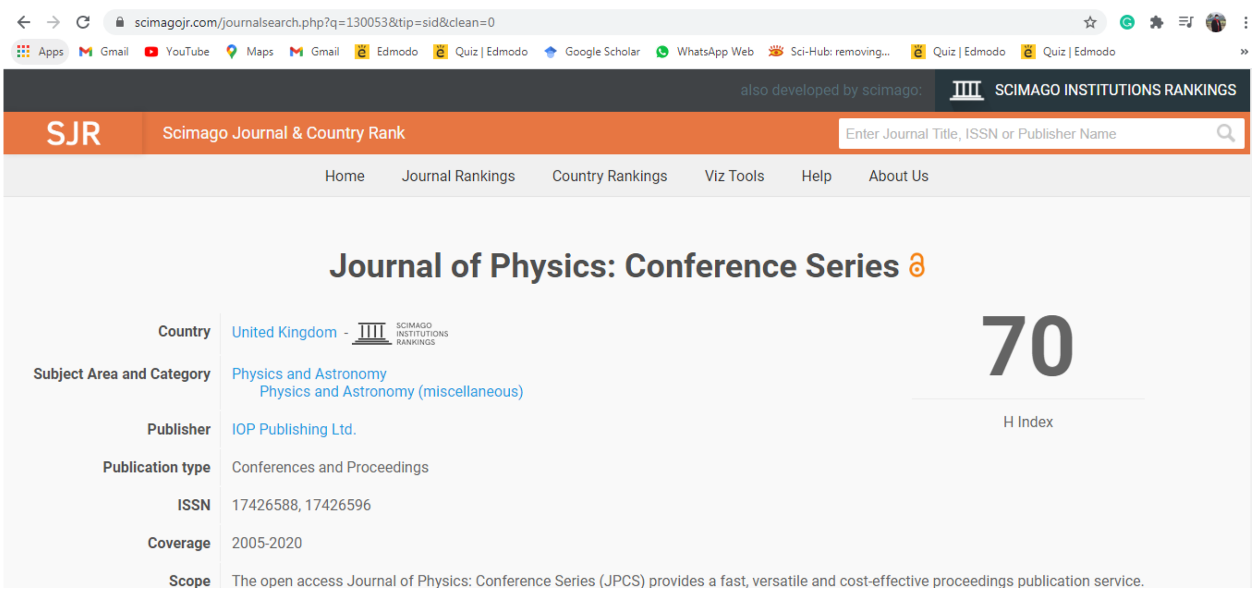


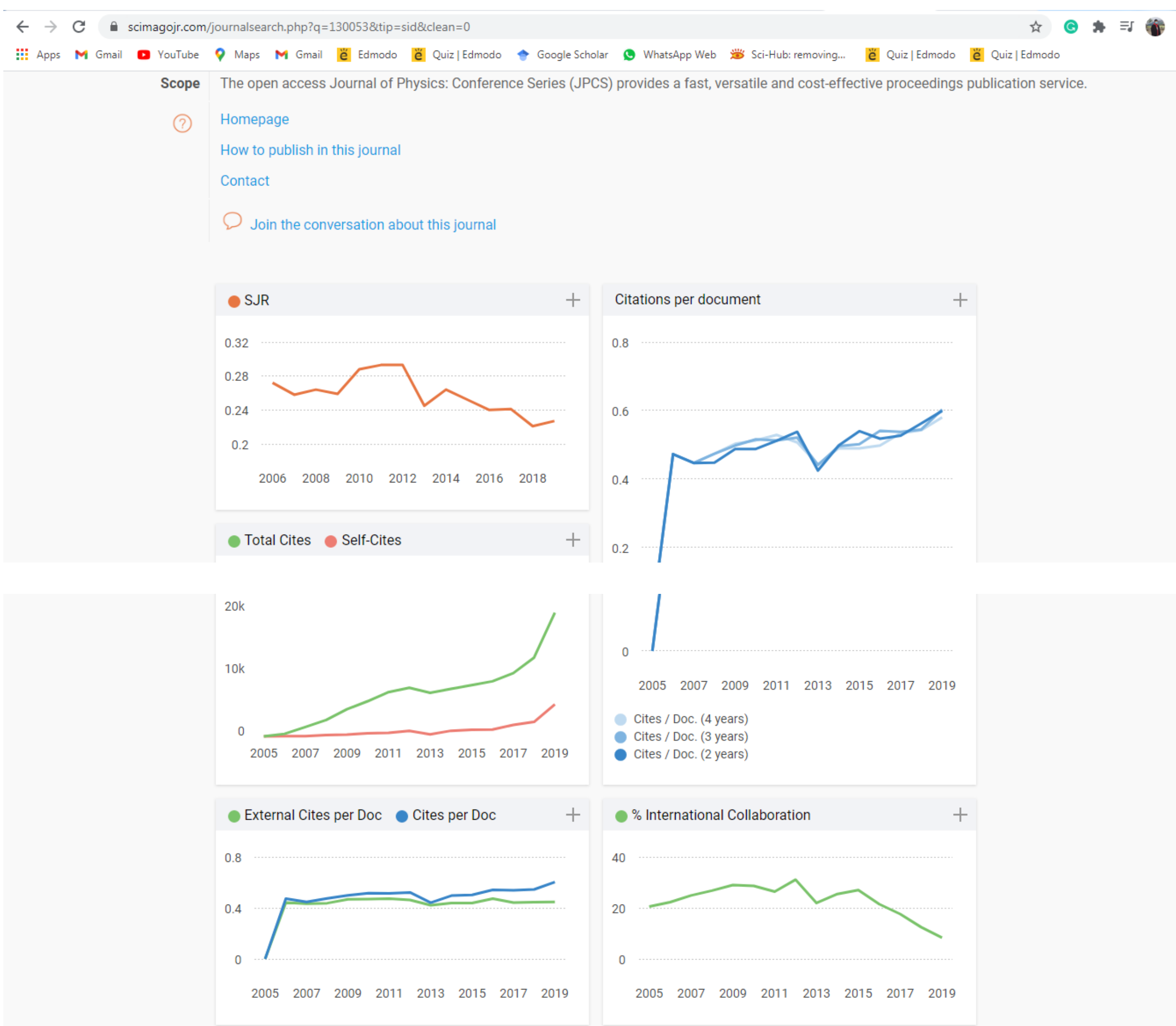

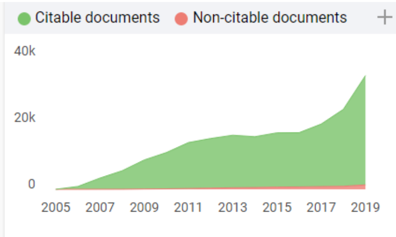


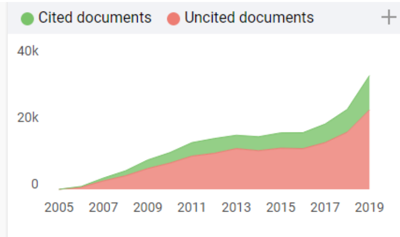


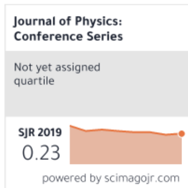


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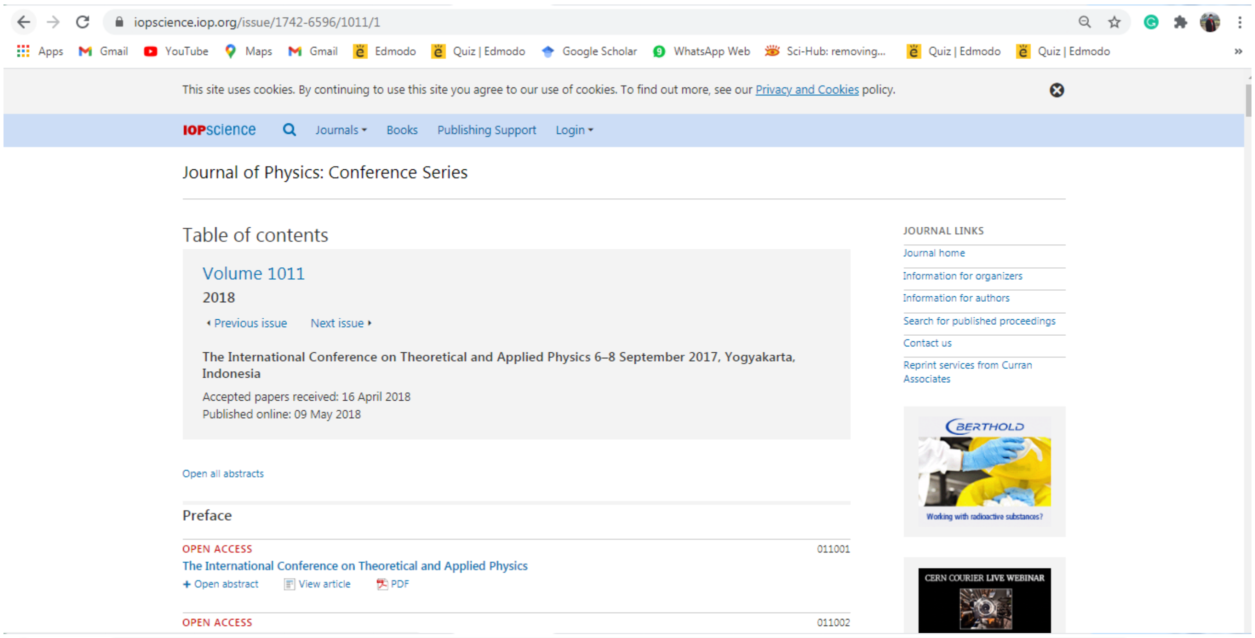
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Accepted papers received: 16 April 2018

Published online: 09 May 2018

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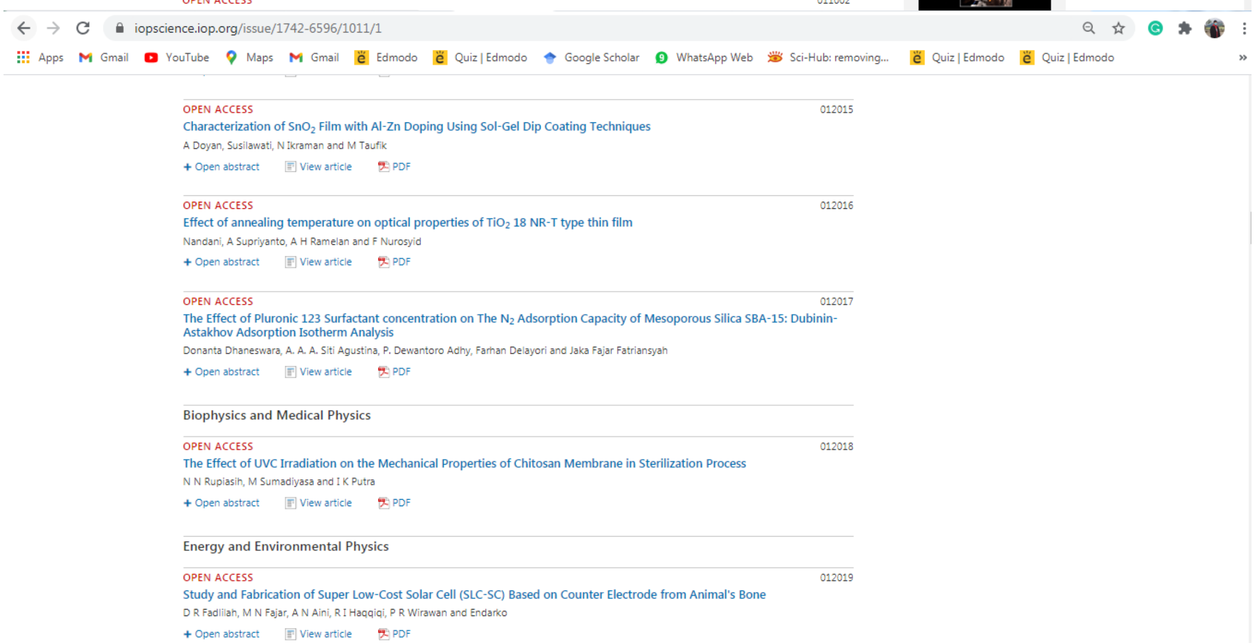
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# Characterization of $SnO_2$ Film with Al-Zn Doping Using Sol-Gel Dip Coating Techniques

A Doyan[1], Susilawati[1], N Ikraman[1] and M Taufik[2]

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Journal of Physics: Conference Series, Volume 1011, The International Conference on Theoretical and Applied Physics 6–8 September 2017, Yogyakarta, Indonesia
Citation A Doyan *et al* 2018 *J. Phys.: Conf. Ser.* 1011 012015



## Abstract

$Sn_{1-2x}Al_xZn_xO_2$ film has been developed using sol-gel dip coating technique. The materials $SnCl_2.2H_2O$, $AlCl_3$ and $ZnCl_2$ dissolved in water and ethanol with 5:95 volume ratio. Variations dopant concentration x = 0.000, 0.005, 0.0025, and 0.050. The film was grown with sol concentration 0.4 M, the withdrawal speed of 12 cm/min and sintering at 600 °C for 30 minutes. The characteristics $Sn_{1-2x}Al_xZn_xO_2$ films





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# Characterization of $SnO_2$ Film with Al-Zn Doping Using Sol-Gel Dip Coating Techniques

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**Abstract.** $Sn_{1-2x}Al_xZn_xO_2$ film has been developed using sol-gel dip coating technique. The materials $SnCl_2.2H_2O$, $AlCl_3$ and $ZnCl_2$ dissolved in water and ethanol with 5:95 volume ratio. Variations dopant concentration x = 0.000, 0.005, 0.0025, and 0.050. The film was grown with sol concentration 0.4 M, the withdrawal speed of 12 cm/min and sintering at 600 °C for 30 minutes. The characteristics $Sn_{1-2x}Al_xZn_xO_2$ films with various doping concentration phase were characterized by XRD. The morphological characteristics and the composition of the constituent elements of the film were characterized by SEM-EDX. The characteristics of the shape, structure, and size of the particles were characterized by TEM. The XRD results show that all films have a tetragonal $SnO_2$ rutile phase without any secondary phase with an average particle size in the range 5.14 – 2.09 nm. The SEM results show that the film grown has a smooth morphology with a striped texture (x = 0.00), and there is a crack (x = 0.050). The EDX results show that the composition and distribution of the constituent elements of the film are uniformly distributed. TEM results show that the particle films has tetragonal rutile structure, orthorhombic and amorphous with a spherical shape.

**Keywords:** Tin oxide, Zinc doping, Al doping, Sol-Gel, Dip Coating

## 1. Introduction

The tin oxide ($SnO_2$) is one n-type transparent semiconductor material with a wide energy band gap (~ 3.6 eV), combines high optical transparency and low resistivity that makes this material applied to solar cells, Liquid Crystal Display and other optoelectronic devices. In addition, $SnO_2$ is very sensitive to the presence of surrounding gas which makes it is applied as gas sensors [1]. Due to its nature and application, the study of $SnO_2$ engineering is very intensive. The preparation and growth of $SnO_2$ film can be done with various techniques such as Chemical Vapor Deposition (CVD) [2], DC and RF Sputtering [3], Pulsed Laser Deposition [4], Chemical Bath Deposition [5], and Sol-Gel Spray Pyrolysis [6], Sol-Gel Spin Coating [7], and Sol-Gel Dip Coating [8]. Of all these methods, Sol-Gel Dip Coating is a very good technique, because it is the simplest one that can grow the film on various forms of the substrate, ease in controlling particle growth and doping, and economical addition.

The characteristics of $SnO_2$ films are known to be enhanced by the addition of doping. Dopants generally have larger or smaller valence electrons with $Sn^+$, and have a similar ionic radius. Dopants may be of a single element such as Sb, F, Zn, Al, Mn or double-shaped elements such as Sb-F, Zn-Co, and others that depend on the application of $SnO_2$ itself. The $SnO_2$ films doped with $Zn^{2+}$ and $Al^{3+}$ ions are known to affect $SnO_2$ properties themselves, including stabilizing $SnO_2$ particles and changing energy band gaps, increasing optical transmittance and electrical conductivity, altering structural, increasing responsiveness, selectivity and stability in sensor gas. However, it is not yet known how the effect of these two dopants

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