Environmental and other applications of Thin-Films

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Abstract: *Thin films become commonly used by the manufacture of wafers, and may be a resistor, a conductor, an insulator or a semiconductor. This paper studies the various application of thin films in the field of display, medical, environmental, solar cells and many electronic fields. Various types of thin-films are studied here. The advantages and how they lack in certain fields are outlined in this paper. Some of the processing techniques of thin films are presented in this current work. The advancement of thin films in the field of Electronics in discussed in this paper.*

Keywords:*Thin-Films, medical, display, environmental, extraction*

1. Introduction

Thin films become commonly used by the manufacture of wafers, and may be a resistor, a conductor, an insulator or a semiconductor. The thin film is indeed a substrate with such a high surface-to-volume proportion [1]. Thin films may also be accumulated via thermal growth or by silicon oxide on a substratum. Thin films have high surface to density proportions but respond differently in certain unique ways against bulk materials with that same chemical composition. Many materials which are complex in terms with conventional tribological undertone including those which are non-abrasive [2] in working circumstances are classified as hard thin films.Thin-film interactive components are made of a complicated alloy. Sputtering enables MEMS quite diverse working thin film systems. The Si-IC dependent micro-fabrication development efficiently integrates all thin film operational structures onto Si wafer.

The development of the single-phase alloy is demonstrated by just a steadying force of stirring entropy [3], as well as the hypothesis of high entropy alloys being adopted as just a metallurgical modelling path.Several high entropy substances provide special properties including incredible higher temperature capacity, high tolerance to oxidation, strong corrosion characteristics, and high resistance [4-5] to radiation respectively.Some analyses focused onto the high entropy principle were performed out coarse substances, but perhaps the thin film group often showed considerable deposition, microstructure or characteristics of HEA materials.Ferroelectric materials are most often used in quite a range of industrial, diverse-spread materials; microwave electronic equipment and micro systems including pyro electric or piezo electric micro sensors / pneumatic cylinders.

2. COMPARATIVE STUDY ON THIN FILMS

This section covers all the applications in the field of display, medical, environmental and solar cells.

2.1 Medical applications

The organic semiconductors [6] finds a vast applications in the medical field because they provide stable operation and also good charge transport. Such devices are very thin and very much flexible. These devices are fabricated on a large scale entirely by printing [6]. These devices can be easily attached to the skin or it can also be wrapped to the limbs. The wearer would not feel any discomfort; these devices can even bent or folded so that they can cope up with the actual movements of the wearer. In [6], Parylene-C films are used to attach to the layer having very less adhesive strength. The layer is used as a release layer with weak adhesive strength. This enables the devices to peel off the supporting plates. The organic material had large crystal domain of 30µm approx. These makes the single crystal will extend between short region of source and drain. These devices provide excellent air stability [6].

In [7], the fabrication of the heat-resistant TFTs are presented. These TFTs operate at voltage of 2V and it has 1.2 $cm^2V^{-1}s^{-1}$ of field mobility. The work presents electrical performance with varying heat. The variation in performance was negligible up to the temperature of 120^0C. The further stability can be provided by annealing at elevated temperature before operation. Dinaphthothienothiophene [7] was used to realise the heat resistant TFTs. The gate dielectric was realised using the combination of aluminium oxide and alkylphosphonic acid. These electrical properties at 30^0C and once again at 40^0C after 30 minutes. The devices were cooled at 30^0C back and the properties were measured back. The same transistors were heated at 50^0C and again cooled to 30^0C.The procedure was carried out between 30^0C and 160^0C with 10^0C change steps. The work was done in nitrogen filled glove box [7]. The resultant was that the drain current at the drain source voltage of -2V decreased after annealing at 100^0C. This was in good relation with [8].

Thin-films has very good compatibility with human cells [9]. In absence of inflammatory response [10], the study of diamond like films involves ML-1 cells, human embryo kidney and osteo-blast like cells. These thin films type are also used in orthopaedic, implantable MEMS applications. These type of thin films are also used in cardiovascular devices such as artery stents and artificial hearts [11-13]. The drainage tubes and hard contact lenses use these types of thin-films. Diamond like thin films also finds the applications in implantable sensor coatings. The DLC films has advantages such as it blocks oxygen which pass through bottles because of its gas barrier properties [14].

2.2 Display Applications

The paper [15], they used thin films and powders especially for Field emission display purposes. They used spin coating method to create thin films. In paper [16] they have inspected the different properties of phosphor thin films to be optimized for increasing the brightness. In [17] the enhancement made on organic TFT made it useful in optoelectronics applications.

The paper[18] proposed wafer-scale processing of separated carbon nanotube TFTs to overcome the disadvantages of relatively high temperature for processing and low mobility of the silicon based TFTs for the display application. The method can be used as a base for the nanotube based display applications because of the processing compatibility and increased mobility.

As the growth of flat panel display including LCDs and OLED (Organic Light Emitting Diode) gives direction towards to flexible displays. Instead of a rigid substrate like glass, flexible displays use plastic substrates. For that purpose, OLED is the best suitable method rather than the LCD because of its advantages like lightweight and operate without rigid backlight. In [19] uses High-Performance Oxide Thin-film Transistor for creating high-resolution large screen displays. In [20] uses the oxide Thin Film Transistors for creating large size flexible displays. In [21], it uses carbon nanotube TFTs and circuits for flexible display applications.

2.3 Environmental applications

In a study conducted in 2006, Hyeok Choi[22] used novel chemistry method for the fabrication of titanium photo catalyst which can be used in the development of effective efficient photo catalytic systems for treatment of water. In this study Mr Choi used Simple synthesis methods of dip coating of substrates into organic Sol composed of isopropanol acetic acid titanium tetra Isopropoxide Mesoporous photo catalytic titanium oxide and polyoxyethylenesorbitan monooleate surfactant (Tween 80) followed by calcination of the coating at 500°C [22a,22b].

In [23] it is found that the solution is stable by slow hydrolysis followed by condensation reactions without the addition of external water molecules. The Titanium oxide material formed Displayed better structural properties such as regular Pore size, homogeneity, large surface area and better catalytic property. The Anatase phase is found active with small pore size and high crystallinity.

In the study conducted in 2004, Mr Wei Wangproposed that Titanium oxide has great physical and chemical properties in the photo catalytic action for environmental remediation.[23] Titanium oxide nanoparticles can also be obtained from the process of hydrolysis of different types of titanium salts such as titanium(IV)chloride($TiCl_4$) [23], titanium(IV)sulphate [Ti-$(SO_4)_2$] [23a]and titanium alkyloxide($Ti(OR)_4$) [23b,23c].

In the study it is found out that the rutile nano particles can be formed but with irregular shapes and high polydispersivity. Though irregular shape, but on the addition of alcohol the shape becomes rodlike. The shapes of the nano material are uniform with equal size distribution.

In the study by Yung fang Chen, It is observed that the titanium oxide nano crystals aresynthesised by hydrolysis of titanium tetraisopropoxide using two surfactants to manufacture the nano crystals [23d]. The titanium oxide nano crystals or nanotubes formed in this synthesis show different phases at different temperatures which are 100°C, 500°C and 800°C.In this study it is found that the Nano materials are having homogeneity with uniform shape and size. Both the Anatase and the rutile phase formation was observed at different temperatures. The surface area is also found to be large [23e].

2.4 Solar Applications

Solar cell with perovskite thin film have the ability to absorb photons from sunlight and convert into a charge with a nearly 100% efficiency. The perovskite thin film is flexible and has a very efficient power conversion [24].
For increasing the efficiency and cost effectiveness of Thin Film Solar Cell transparent conductive oxides (TCO) can be used along with reflective coating in back contact. This increases the path length of sunlight entering the cell and increases the efficiency [25].
Coating of Plasmon layer on Solar Cell can reduce the cost of devices which run on solar thin film as these thin films can be manufactured using less material. Use of Plasmons layer also increases cell efficiency. This also improves carrier collection, minimizes photo degradationand bulk recombination [26].
By using a polycrystalline C60 heterojunction in solar thin film high efficiency can be achieved due to effective photoelectric conversion of sunlight. The C60 can be compared equivalent to p – type semiconductor as it possess large carrier mobility. It also possess a polycrystalline structure so it can be an effective photovoltaic cell [27].

3. Conclusions

The studies on the applications of thin films in the field of electronics and its sub fields are presented in this paper. The formation of nano particles of titanium oxide can be obtained by calcination as well as hydrolysis. According to my observations the formation of titanium oxide with two Surfactant which were TEM and NP-204 is better as the Anatase as well as rutile phase both can be observed at different temperatures.The organic semiconductors finds a vast applications in the medical field because they provide stable operation and also good charge transport. The DLC films has advantages such as it blocks oxygen which pass through bottles because of its gas barrier properties.By using a polycrystalline C60 heterojunction in solar thin film high efficiency can be achieved due to effective photoelectric conversion of sunlight.

REFERENCES

[1]. Tomoaki Matsushima, IsakuKanno, KiyotakaWasa. Thin Film MEMS. Handbook of Sputter Deposition Technology. 2012

[2]. Smolenskii GA, Bokov VA, Isupov VA, Krainik NN, Pasynkov RE, Sokolov AI. Ferroelectrics and related materials. In: Taylor GW, editor. Ferroelectricty and related phenomena, vol. 3. New York, NY: Gordon and Breach;1984.

[3]. N Setter et al. Ferroelectric thin films: review of materials, properties and applications. Journal of Applied Physics 100, 051606 (2006). DOI: 10.1063/1.2336999

[4]. A. K. Tagantsev, V. O. Sherman, K. F. Astafiev, J. Venkatesh, and N. Setter, J. Electroceram. 11, 5 2003

[5]. A. Gruverman and M. Tanaka, J. Appl. Phys. 89, 1836 .2001.

[6]. Fukuda, K. et al. Fully-printed high-performance organic thin-film transistors and circuitry on one-micron-thick polymer films. Nat. Commun. 5:4147 doi: 10.1038/ncomms5147 (2014).

[7]. Kuribara, K. *et al.* Organic transistors with high thermal stability for medical applications. *Nat. Commun.* 3:723 doi: 10.1038/ncomms1721 (2012).

[8]. Sekitani, T., Iba, S., Kato, Y. &Someya, T. Pentacene field-effect transistors on plastic films operating at high temperature above 100°C. Appl. Phys. Lett. 85, 3902–3904 (2004).

[9]. Roger J. Narayan. Nanostructured diamond like carbon thin films for medical applications. Materials Science and Engineering C 25 (2005) 405 – 416. Doi: /10.1016/j.msec.2005.01.026

[10]. M. Allen, F. Law, N. Rushton, Clin. Mater. 17 (1994) 1.

[11]. I. Dion, X. Roques, C. Baquey, E. Baudet, B. Basse, N. More, Bio- Med. Mater. Eng. 3 (1993) 51– 55.

[12]. G.F. Yin, J.M. Luo, C.Q. Zheng, H.H. Tong, Y.F. Huo, L.L. Mu, Thin Solid Films 345 (1999) 67.

[13]. K. Yamazaki, P. Litwak, O. Tagusari, T. Mori, K. Kono, M. Kameneva, M. Watach, L. Gordon, M. Miyagishima, J. Tomioka, M. Umezu, E. Outa, J.F. Antaki, R.L. Kormos, H. Koyanagi, B.P. Griffith, Artif. Organs 22 (1998) 466.

[14]. Akira Shirakura et al. Diamond-like carbon films for PET bottles and medical applications. Thin Solid Films 494 (2006) 84 – 91. DOI: 10.1016/j.tsf.2005.08.366

[15] D. Ravichandran et al. "Fabrication of $Y_3Al_50_{12}$: Eu thin films and powders for field omission display applications". Journal of LuminescenceVolume 71, Issue 4, May 1997, Pages 291-297. DOI: 10.1016/S0022-2313(96)00137-8

[16] RK Singh et al. "critical issues in enhancing brightness in thin film phorphors for flat panel display applications", Applied Surface Science. Volumes 197–198, 30 September 2002, Pages 321-324. DOI: 10.1016/S0169-4332(02)00390-2

[17] H. Klauk, D. J. Gundlach, J. A. Nichols and T. N. Jackson, "Pentacene organic thin-film transistors for circuit and display applications," in IEEE Transactions on Electron Devices, vol. 46, no. 6, pp. 1258-1263, June 1999.

[18] Chuan Wang, Jialu Zhang, KoungminRyu, Alexander Badmaev, Lewis Gomez De Arco, and Chongwu Zhou Wafer-Scale Fabrication of Separated Carbon Nanotube Thin-Film Transistors for Display Applications Nano Letters 2009 9 (12), 4285-4291 DOI: 10.1021/nl902522f

[19] M. Nakata, Y. Nakajima, H. Tsuji, T. Takei, Y. Fujisaki and T. Yamamoto, "High Performance oxide thin-film transistor for large-screen, high-resolution organic light-emitting diode display," 2016 IEEE Industry Applications Society Annual Meeting, Portland, OR, 2016, pp. 1-5.

[20] M. Nakata et al., "Oxide thin-film transistor technology for flexible organic light-emitting diode displays," 2015 IEEE Industry Applications Society Annual Meeting, Addison, TX, 2015, pp. 1-5.

[21] Fang, Yan, Sun, Wang and Sun, "Carbon nanotube thin-film transistors and driving circuits for flexible display application," 2016 7th International Conference on Computer Aided Design for Thin-Film Transistor Technologies (CAD-TFT), Beijing, 2016, pp. 1-1.

[22]. H Choi eat al, Sol-Gel Preparation of Mesoporous PhotocatalyticTiO_2 films and TIO_2/Al_2O_3 composite membranes for environmental application, Applied Catalysis B: Environmental 63, 2006, 60-67.

[22a]. M. R. Hoffmann, S. T. Martin, W. Choi, and D. W. Bahnemann, "Environmental applications of semiconductor photocatalysis," *Chemical Reviews*, vol. 95, no. 1, pp. 69–96, 1995

[22b]. K. Rajeshwar, M. E. Osugi, W. Chanmanee et al., "Heterogeneous photocatalytic treatment of organic dyes in air and aqueous media," Journal of Photochemistry and Photobiology C, vol. 9, no. 4, pp. 171–192, 2008.

[23]. Wei Wang et al, Synthesis of Rutile Nano Crystals with Controlled Size and Shape by Low-Temperature Hydrolysis: Effects of Solvent Composition, The Journal of Physical Chemistry B, 2004, 108 (39).

[23a]Matijevic et al, Production Of Monodispersed Colloidal Particles, Department of Chemistry, Institute of Colloid and Surface Science, Clarkson University, Potsdam, New York 13676

[23b]Jae Young Choi et al, Preparation of Monodisperse and Spherical Powders by Heating of Alcohol-Aqueous Salt Solution, Journal of Sol-Gel Science and technology volume 15, pages 231-241.

[23c]Barringer Eric A et al, High-purity, monodisperse TiO2 powders by hydrolysis of titanium tetraethoxide. 1. Synthesis and physical properties, ACS Publication, 1985, 1, 4,414-420.

[23d]Yung-Fang Chen et al, Preparing titanium oxide with various morphologies, Materials Chemistry and Physics 81 (2003) 39–44

[23e]Sun-Jae Kim et al, Photocatalytic Effects of Rutile Phase TiO2 Ultrafine Powder with High Specific Surface Area Obtained by a Homogeneous Precipitation Process at Low Temperatures, Journal of Sol-Gel Science and Technology volume 22, pages63–74(2001)

[24]. James M. Ball et.al. Low-temperature processed meso-superstructured to thin-film perovskite solar cells, RSC, Energy Environ. Sci., 2013, DOI: 10.1039/c3ee40810h

[25]. Joachim Muller et al. TCO and light trapping in silicon thin film solar cells, 2004 Elsevier Ltd, doi:10.1016/j.solener.2004.03.015

[26]. P Spinelli et al. Plasmonic light trapping in thin-film Sisolar cells, IOP Publishing, 2012, doi:10.1088/2040-8978/14/2/024002

[27].S. Yoo, B. Domercq, and B. Kippelen, Efficient thin-film organic solar cells based on pentacene/ C 60 heterojunctions, : Applied Physics Letters 85, 5427 (2004); doi: 10.1063/1.1829777