Materials Physics and Mechanics 18 (2013) 1-10 Received: September 17, 2013

1/f NOISE STUDIES ON THIN FILMS OF CADMIUM OXIDE

S. Victor Vedanayakam[1*], D. Punyaseshudu[2]

[1]Dept. of Physics, MITS, Madanapalli, A.P., India

[2]Dept.of Physics, Rayalaseema University, Kurnool, A.P., India

*e-mail: victorvedanayakams@mits.ac.in

Abstract. 1/f noise and nonlinear effects in Cadmium Oxide thin films for different current densities on varying the thickness of the films, at room temperature are studied. The specific dependence of 1/f noise on the thickness of the film, the effect of current densities on 1/f noise for the films of various thicknesses (300 Å to 750 Å) has been investigated. It is noticed that, for a constant current, the thickness of the film leads to an increase of 1/f noise. 1/f noise plays an important role in choosing frequency band in which a device can be effectively used. Cadmium oxide thin films are regarded as a material with many attracting properties such as large energy band gap, good conduction, high transmission coefficient etc. It is specially used in optoelectronic devices.

1. Introduction

Cadmium Oxide (CdO) thin films are having remarkable characteristics. They have found extensive applications in electronic and optical devices. The wide band gap properties of CdO, are of interest particularly for applications such as solar cells and transparent electrodes. Measurements of nonlinear properties are very interesting from the point of the view of optoelectronic and all optical switches. Hence these films are studied in the present work. Using the newly developed measuring system the studies are undertaken and found that the results are matching the theoretical values.

1/f noise plays an important role in choosing frequency band in which a device can be effectively used. As 1/f noise comes from the fluctuations of microscopic entities, it can act as a probe of what is happening physically at the microscopic scale. Characterization of noise with a 1/f like spectrum, and referred to as an excess or flicker noise, provided most important problems in modern radio physics. This noise limits the sensitivity and stability or many radio electronic devices, the requirements to which are enhancing constantly.

These fluctuations reflect many processes at the electron and atom levels and specific features of solid state micro-structure which makes 1/f noise a valuable informative parameter for evaluating the quality of materials and reliability of devices containing semiconductors and integrated micro chips. It is also used to predict the electro migration immunity of thin film metallization in integrated micro chips.

Recently, there has been sharply increasing interest in 1/f noise in thin metal films and other physical systems, which can be accounted for their wide application in different areas of physics and technology, especially in modern micro-electronics which makes high demands of thin films of different materials in manufacturing commutation layers, resistors, and contacts for integrated microcircuits.

1/f noise phenomenon was first studied as an excess low frequency noise in vacuum tubes and later in semiconductor devices. Since the mid-fifties 1/f noise (referred as low frequency noise) has been observed as fluctuations in the physical parameters of the systems.

effects with additional low frequency noise components particularly burst noise.

(3) Stationarity.

A process is said to be statistically stationary when the statistical properties are independent of the epoch in which they are measured. In the 1/f noise literature one comes across statements to the effect that 1/f noise is a stationary fluctuation as well as those saying that it exhibits some degree of non-stationary. In order to clarify the situation, two kinds of noises namely the band limited 1/f noise and low pass filtered 1/f noise have to be studied. The band limited 1/f noise is that for which the power spectral density is defined only for any frequency between the upper and lower angular frequencies of the pass band considered.

(4) Current Dependence.

In homogenous conducting materials, it has been verified that there is a current squared (I^2) dependence of noise, which led to the belief that 1/f noise originates from fluctuations in conductivity. However, in junction devices such as diodes and transistors, the current spectral density is observed to be proportional to I^{γ} with γ between 1 and 2.

(5) Temperature Dependence.

From the above property since 1/f noise depends on current and current depends on temperature, it is to believe that 1/f noise dependence on temperature. The studies of Horn and Bernard have shown the dependence of 1/f noise in metal films on temperature. According to Handel, in semiconductors, there is certain temperature dependence due to absorption and description of gases or water vapor on the surface, due to changes in the concentration of the carriers.

2. Thin films

Thin film science has received tremendous attention in the recent years for their applications in diverse fields such as, electronic industries, military weapon systems, space science, solar energy utilization etc. Thin films are used as optical and superconducting film materials, high memory computer elements, sensors etc.

The thin film properties mainly depend upon the preparative conditions, film structures, and presence of defects, impurities and film thickness. Various physical constants related to the bulk material properties may not often be the same for corresponding films prepared from the bulk. However, with increasing film thickness these tend to assume corresponding bulk values. Numerous applications of films lead to intense studies of these especially to develop and prepare better films with specialized properties for newer compounds or composite materials.

Subsequent developments of the study of thin films revealed that the tailoring of properties is possible by the use of thin film technique. The proper control of compositions and deposition conditions results into tailored micro materials. These materials used in the fields of optics, electrical, optoelectronics and such other applications. Thin film devices and components are preferred over their bulk counterparts, because of compactness, better performance, reliability coupled with less cost of production and low package weight.

Thickness plays an important role in thin films. It is an important parameter, which affects the optical, electrical, structural etc. properties of metals considerably. Reproducible characteristics can be obtained by choosing specific thickness and proper combination of deposition parameters for a particular material.

Cadmium Oxide (CdO) thin films are regarded as a material with many attracting properties such as large energy band gap, good conducting film and high transmission coefficient in visible spectral domain. In recent years, researchers have focused on CdO due to its applications, especially in the field of optoelectronic devices such as solar cells, Phototransistors and diodes, transparent electrodes, gas sensors, etc. These applications of CdO are based on its specific optical and electrical properties. For example, CdO films show a

These graphs convey better information when they are compared for different films of for different conditions for the same DUT. Plotting them on the same graphical presentation compares two or more plots. This is equivalent to superimposing multiple graphs presented on similar scales. To visualize the difference, the graphs are plotted using different colors. A legend to each graph is added for easy explanation. In the present work 1/f noise dependence on different conditions is studied. The 1/f noise plots are carefully compared to achieve the objectivity of 1/f noise studies.

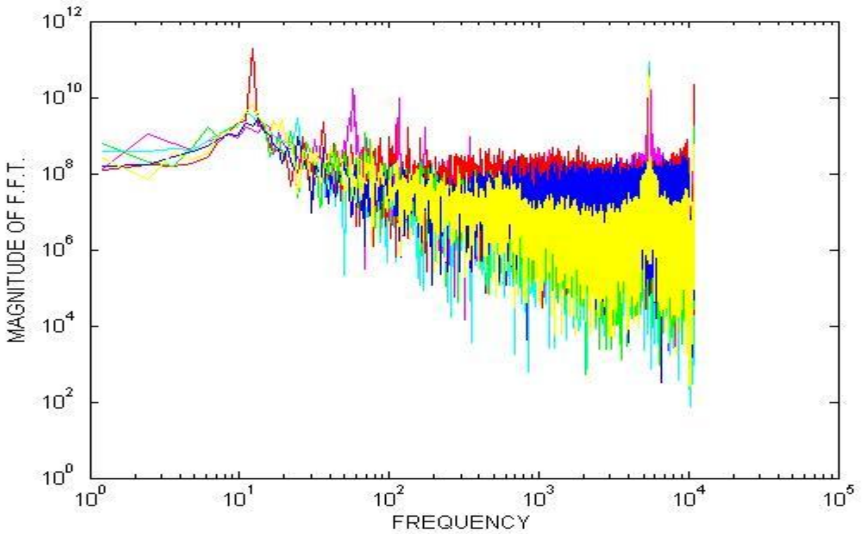

Fig. 2. FFT amplitude of CdO film of thickness 300 Å for different current densities.

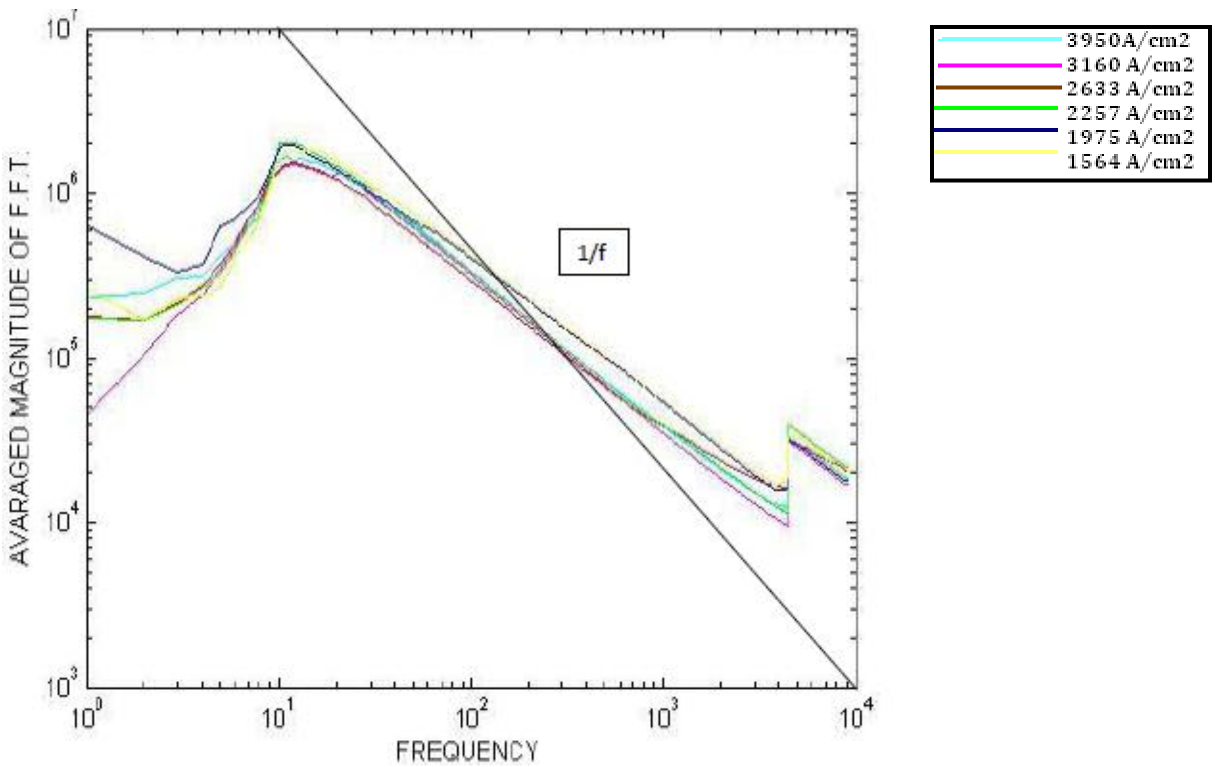

Fig. 3. 1/f noise of 300 Å CdO film at different current densities.

compliance. In this work the 1/f line for every FFT plot is included and also the value of γ evaluated.

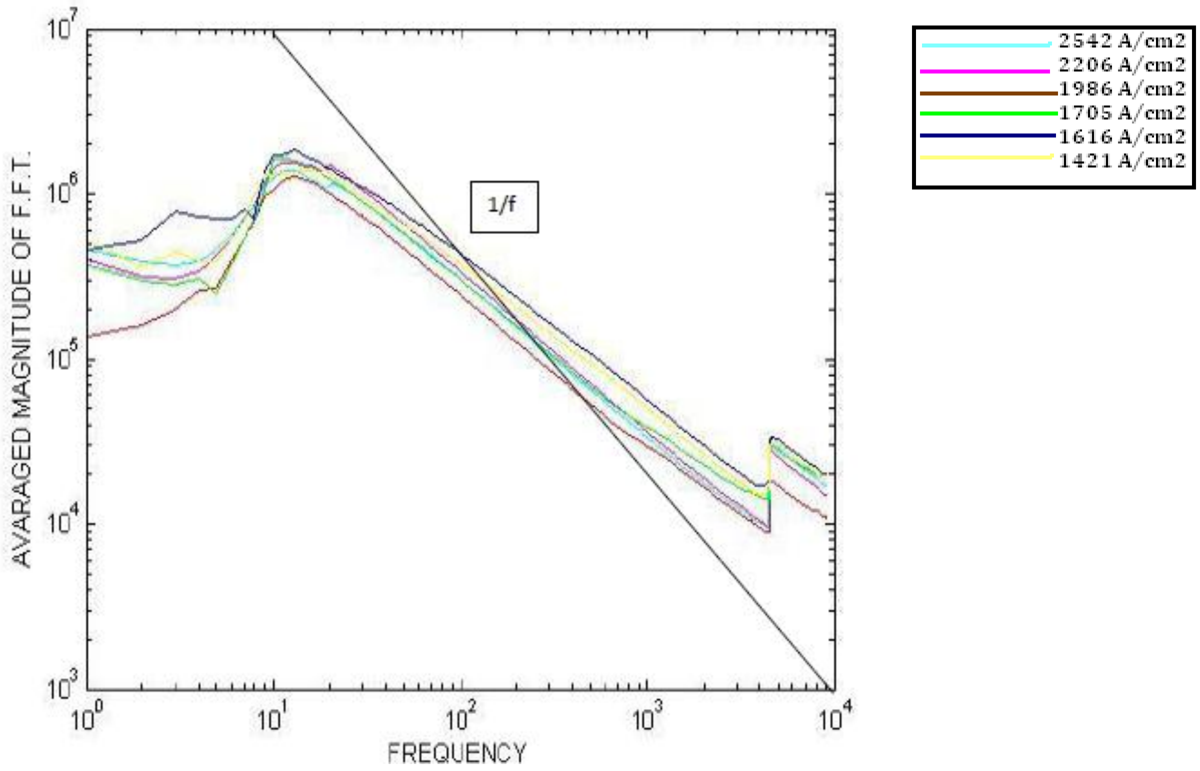

Fig. 6. 1/f noise of 620 Å CdO film at different current densities.

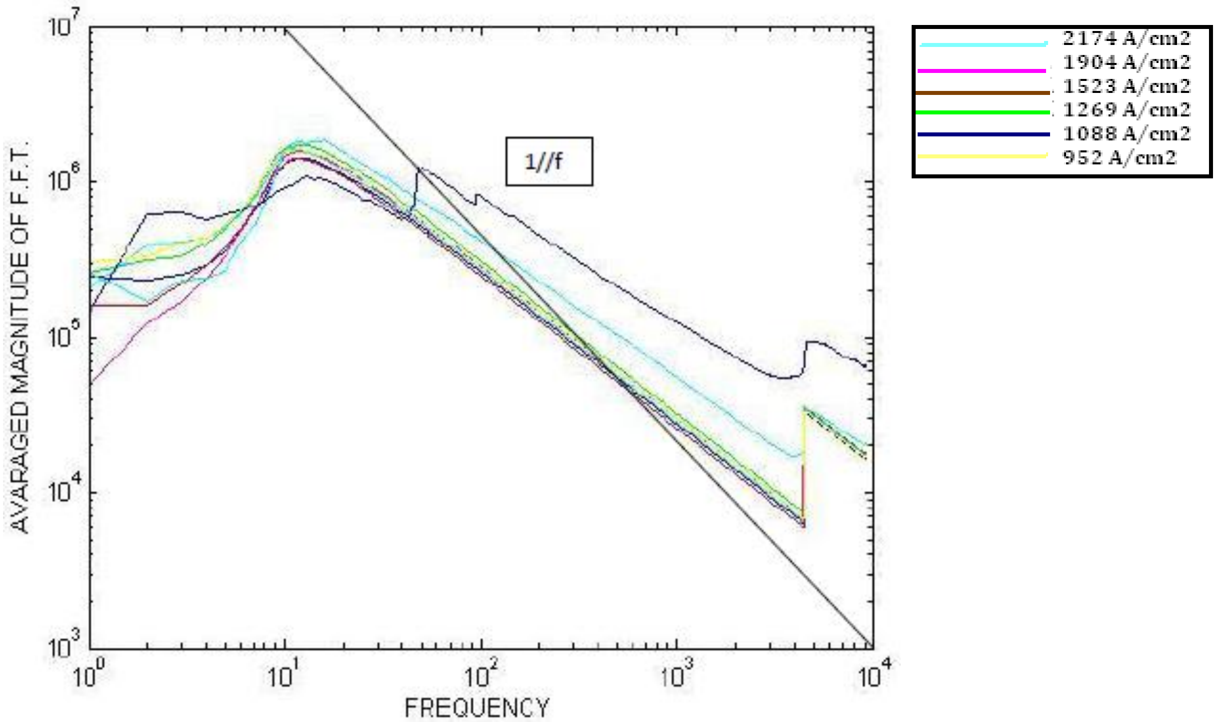

Fig. 7. 1/f noise of 750 Å CdO film at different current densities.

Table 4. γ- Values derived from the figure for various frequency regions in 620 Å CdO film.

Current Density	Bellow 1 KHz Frequency	Between 1 KHz and 10 KHz	Averaged for the full range
2542 A/cm^2	-0.647	-0.594	-0.621
2206 A/cm^2	-0.662	-0.622	-0.642
1986 A/cm^2	-0.696	-0.616	-0.656
1705 A/cm^2	-0.744	-0.656	-0.700
1616 A/cm^2	-0.784	-0.752	-0.768
1421 A/cm^2	-0.798	-0.768	-0.783

Table5. γ- Values derived from the figure for various frequency regions in 750 Å CdO film.

Current Density	Bellow 1 KHz Frequency	Between 1 KHz and 10 KHz	Averaged for the full range
2174 A/cm^2	-0.712	-0.694	-0.703
1904 A/cm^2	-0.756	-0.720	-0.738
1523 A/cm^2	-0.789	-0.733	-0.761
1269 A/cm^2	-0.811	-0.741	-0.771
1088 A/cm^2	-0.826	-0.784	-0.805
952 A/cm^2	-0.853	-0.811	-0.832

Table 6. Average slopes of various 1/f graphs at the specific current density in CdO films.

S. No	Figure number	Description	Color of graph	Thickness	Average slope γ
1	Fig. 5.14	10 mA through CdO films of different thickness.	Magenta	300 Å	-0.605
			Cyan	380 Å	-0.668
			Red	500 Å	-0.744
			Green	620 Å	-0.827
			Blue	750 Å	-0.914
2	Fig. 5.15	15 mA through CdO films of different thickness.	Magenta	300 Å	-0.526
			Cyan	380 Å	-0.574
			Red	500 Å	-0.655
			Green	620 Å	-0.778
			Blue	750 Å	-0.873
3	Fig. 5.16	20 mA through CdO films of different thickness.	Magenta	300 Å	-0.500
			Cyan	380 Å	-0.560
			Red	500 Å	-0.600
			Green	620 Å	-0.742
			Blue	750 Å	-0.812

4. Results and conclusions

The results of present study on 1/f noise of CdO are very interesting.

1. The γ value appears to decrease with increase in thickness and seem to tend to 1 at higher thickness. The γ value also appears to settle down to -0.5 for lower thickness.

2. In similar manner 1/f plots of the five samples at constant currents of 10 mA, 20 mA and 30 mA. The –γ values are evaluated and plotted, the behavior is almost similar to that presented in the case of current densities.

3. It is observed that, for a given film, the –γ values decrease and appear to tend to minus one for diminishing currents or current densities.

4. It is noticed that for a constant current, decreasing the thickness of the film leads to an increase of the γ value in CdO films.

5. In these films the magnitude of noise is increasing while γ is decreasing with increasing current density.

References

[1] A. Van der Ziel, In: *Proc. of the Symposium on 1/f Fluctuations*, I. Int. Conf. on 1/f Noise, ed. by T. Musha (Tokyo Institute of Technology Press, Tokyo, Japan, 1977), p 1.

[2] C.M. Van Vliet // *Solid State Electron.* **34** (1991) 1.

[3] D.S. Campbell, In: *The Use of Thin films in Physical Investigations*, ed. by J.C. Anderson (Academic Press, London - New York, 1965), p. 299.

[4] F.N. Hooge // Physica B+C **114** (1982) 391.

[5] A. Goswami, *Thin Film Fundamentals* (New Age International Publisher, New-Delhi, 1966).

[6] L.I. Maissel, In: *Hand Book of Thin Film Technology*, ed. by L.I. Maissel, R. Glang (McGraw-Hill, New York, 1970).

[7] John G. Proakis, Dimitrtis G Manolakis, *Digital Signal Processing: Principles, Algorithms, and Application* (Prentice Hall, 1995).

[8] L.A. Udchan, M.S. Jogad, Rao S. Rama // *Asian J. Phys.* **8** (1999) 207.

[9] F.N. Hooge, T.G.M. Kleinpenning, L.K.J. Vandamme // *Rep. Prog. Phys.* **44** (1981) 479.

[10] J.S. Walker, *Fast Fourier Transforms, Studies in Advanced Mechanics* (CRC Press, 1996).