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QUARTZ CRYSTAL FOR THICKNESS MEASUREMENT

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***Abstract*— In this paper, Quartz sensor kept along the side of the substrate measures the deposited film thickness by monitoring change in its resonance frequency. The change in the quartz crystal resonance frequency due to deposition decreases linearly with thickness. Thus the change in frequency gives the measurement of film thickness deposited on a substrate. Quartz crystal has been excited to its resonance frequency of 5 MHz and measures the shift in frequency of the Quartz due to the deposited material on it during the deposition on the substrate with an embedded PSoC design. The change in frequency count data will be sent to PC through its serial port. Virtual instrument program written in LabVIEW acquires the frequency data and convert it to as a thickness of a coated material.**

***Index terms - Quartz Crystal, Microcontroller, Virtual Instrument Programming*.**

I. INTRODUCTION

A single quartz crystal wafer with AT cut (Plano convex), of 5 MHz frequency with 20 mm x 20 mm size, with two pairs of circular gold electrodes deposited on it has been used to measure the thickness of thin films coated during deposition. The use of a quartz crystal monitors thin film thickness determinations, during deposition by the vacuum evaporation technique [1]. This is based on the principle that a quartz crystal has a well defined resonance frequency which depends on its cut and geometrical dimensions as the film is deposited on one side of the electrode pair of the quartz plate, a change in resonance frequency takes place corresponding to the mass of the film deposited.

Quartz crystals

Quartz crystals are piezoelectric materials and are widely used in frequency control applications because of their unequalled combination of high Q factor, stability, small size and low cost[2]. The mechanical resonator such as tuning fork and piezoelectric ceramic resonators on single crystal material is the unique combination. Thus it is an electromechanical transducer. AT-cuts are commonly manufactured in the frequency range from 1 MHz to 250 MHz.

Figure 1 Quartz Crystal (AT cut)

II. MATERIAL AND METHOD*:*

The measurement thickness of thin films during coating of the material. Each of electrodes of the quartz crystal is connected to two separate identical oscillator circuits, the outputs of which, after proper amplification, are passed through a mixer followed by a low pass filter and an amplifier; the frequency is then measured by a PSoC frequency Counter[4]. The change in the frequency will now be proportional to the thickness of the film coated on the quartz crystal. The resultant output frequency is recorded on a Lab VIEW recorder which gives an indication of the coating thickness. The film thickness measuring range of the quartz crystal fitted with suitable exciter electrodes is decisively dependent on the coating material being evaporated.

The quartz crystal is a 5 MHz-AT-fundamental crystal with a small temperature coefficient. Coated areas from gold, silver or aluminum are used as energizing electrodes. The measuring area is coated entirely with one of these materials.

Measuring method

When using this method, the change of the natural frequency f in a quartz crystal whose thickness d has been increased by the amount of Δd after applying a mass, e.g. by depositing a foreign layer on the quartz plate, is measured. With the transfer function given below the thickness of the coating material can be easily evaluated. Change in Natural Frequency, $\Delta f / f = - \Delta d / d = - \Delta m / (\rho q . F.d)$ where ρq = density of the quartz, F= area of the quartz and Δm = mass of a foreign layer covering the quartz plate homogeneously from which the thickness of the coated layer can be obtained $d_s = K/ \rho s [1/f – 1/f_0]$ where d_s – thickness of the

coated layer, ρs – Sp. Density of the coating material, f_0– Natural frequency, f-frequency measured, K=constant. The frequency emitted by the oscillator (quartz crystal) is electronically multiplied and measured per second. PSoC calculates the thickness of the layer from the difference of the frequency and the coating rate from the change of the frequency as a function of time.[3]

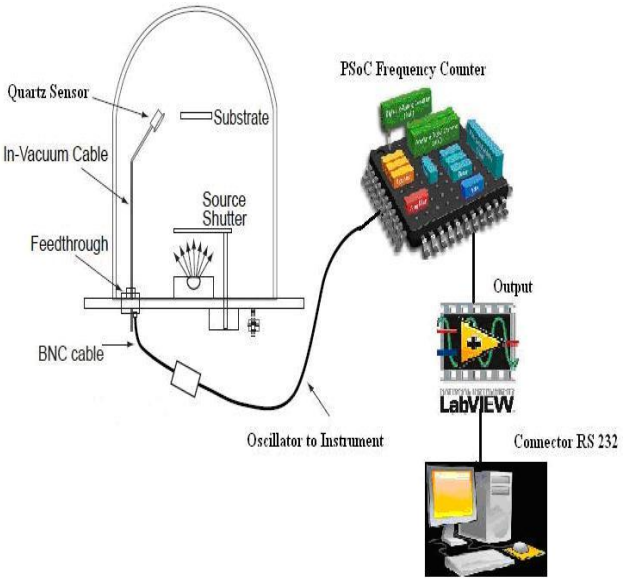

Figure 2 Block diagram of Thin Film Thickness monitor and measurement using PSoC and LabVIEW

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MATERIAL	SENSITIVITY
Silver	Approx.50Hz/nm
Copper	Approx.42Hz/nm
Aluminum	Approx.13Hz/nm
Nickel	Approx.42Hz/nm
Niobium	Approx.40Hz/nm
Germanium	Approx.25Hz/nm

Table.1 Sensitivity of quartz crystal for different materials

Thickness Measurement

Programmable system on chip and Virtual instrument programming with LabVIEW has been carried out to find the thickness of the thin film during deposition[4]. The quartz crystal is thus excited to its resonance frequency of 5 MHz and its DC shifted output after removing 5 volts DC offset with a discrete external pulse clipping circuit is fed to a PSoC counter to read the data. The output of oscillator is quite stable[5]. PSoC read-out measures the shift in frequency of the Quartz due to the deposited material on it during the deposition on the substrate. The change frequency count data will be sent to PC through its serial port. Virtual instrument program written in LabVIEW acquires the frequency data and convert it to as a thickness[6]. On-line plotting and saving into a user specified file path has been carried out by the graphical user interface menu driven program[7].

III. CONCLUSION

A PSoC based embedded system design for thin film deposition measurement in BALZERS coating system has been successfully carried out. The thin film whose thickness is to be measured was deposited on one side of one electrode pair while the other pair was kept covered from deposition. The resonance frequencies of the two electrode system were then processed in a conventional manner and the frequency was measured by a PSoC counter module. The output has been analyzed in a PSoC Counter and the resulting output frequency plotted on a LabVIEW was proportional to the thickness of thin films coated during deposition. Thus, the change in frequency due to thin film deposition on the crystal has been evaluated for the thickness of the thin film deposition on the substrate kept nearby Quartz crystal.

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