Final Report Summary

Review of novel measurement techniques for crystal based thin film monitors

Intellevation Ltd
http://www.intellemetrics.com

University of Paisley
http://www.paisley.ac.uk

This work evaluates existing competitive crystal thin film thickness measurement techniques and examines the feasibility of developing and implementing a new and novel crystal frequency measurement technique. The investigation was carried out by two partners Intellevation Ltd and the School of Computing at the University of Paisley.

Based on the fact that the change in resonant frequency of the piezoelectric crystal was related to the mass of material deposited, the use of resonant piezoelectric crystals as the sensing element for the thickness measurement of thin films was first implemented over 50 years ago. The underlying principle has changed little to this day, apart from the techniques used to measure the change of the resonant frequency. The piezoelectric crystal forms the feed back loop of an oscillator and the frequency of this oscillator is measured. Several techniques exist for the accurate measurement of the oscillator frequency.

The work carried out in this study has identified that other frequency measurement techniques may be utilised for this application. Alternative techniques are used in RF communications for the demodulation of FM signals. Essentially the change in resonant frequency of the resonating crystal is equivalent to a change in frequency of an FM signal so the standard FM demodulation techniques are potentially applicable.

The most common demodulation techniques are homodyne and heterodyne detection, zero crossing detection and phase locked loop (PLL) detection. The first two demodulation techniques involve taking the signal from the sensing crystal and mixing this through a nonlinear element with a frequency from a stable reference oscillator. If the reference oscillator set at the same frequency as that of the unloaded crystal then this is referred to as homodyne detection. The output from the mixer is then the sum and difference frequencies between the reference oscillator and the sensing crystal. In homodyne detection the mixer output is simply the frequency difference between the reference signal and sensing crystal frequency.

Development of the measurement techniques identified could have a major technological design impact on the current design methodology and on future products created by Intellevation. As the techniques proposed involves significant signal processing, it is clear that a first step in the design cycle for the next generation of products is utilisation of an embedded PC based instrument to provide the necessary computational power and system configuration for future upgradeability and configuration flexibility.

In conclusion, the TTOM project has identified two possible approaches in the development of crystal based thin film thickness measurement techniques for the company. To capitalise on the proposed measurement ideas outlined above, further research is essential to assess the feasibility of these techniques and subsequently realise their full potential.

Delivered by the Scottish Optoelectronics Association

Co-funded by: PROJECT PART-FINANCED BY THE EUROPEAN UNION — Europe and Scotland Making it work together — SCOTTISH EXECUTIVE — Scottish Enterprise