*Frontier Semiconductors, [www.frontiersemi.com](http://www.frontiersemi.com),*
*Abstract submitted for 2005 ULSI Conference on 11/3/2004 3:19 PM*

# Fiber-optics low-coherence integrated metrology for in-situ non-contact characterization of novel materials and structures

Wojciech J. Walecki*, Alexander Pravdivtsev, Kevin Lai, Manuel Santos II, SH Lau, and Ann Koo

Frontier Semiconductor, 1631 North 1st Street, San Jose CA 95112

Keywords: Thin-Film Metrology; Diagnostics; In-Situ, Real-Time Control and Monitoring;

Low coherence optical interferometry [1] has been proven to be an effective tool for characterization of thin and ultra-thin semiconductor Si and compound wafers [2], and MEMs structures [3]. In this paper we explain extension of this method to characterization of strained Si wafers, SOI and other novel structures.

The metrology of stress and topography of silicon wafers is a mature field. Available solutions are based on large aperture optical interferometers, capacitance, and laser scanning tools.

Free space optical interferometers for 300 mm are expensive due tpo high cost of optics and precision mechanical mounts. Due to large dimensions, and mass of optical components they are rather difficult to integrate for in-situ applications and their integration with other complementary metrologies is usually quite cumbersome.

Capacitance method however is not suitable for measuring thickness of semi-insulating and insulating materials, and does not provide insight in the internal structure of layered systems such as SOI.

Laser scanning tools are offering several advantages over two earlier mentioned technologies. Laser scanning tools are easier to adapt in integrated environment, and have great potential for in-situ application. They do suffer however from certain limitations of accuracy inherent to scanning technology.

In our paper we propose technique based on our recently developed dual probe low coherence interferometer. We demonstrate that this novel technology has capability to evaluate both surface topography and thickness of measured layers with reproducibility of 50 nm (in laboratory conditions). Example of experimentally measured topography of strained silicon wafer is shown in Figure 1. Specifications for stress measurement on uniform wafers and covered by uniform films is presented in Table 1.

Due to small probe size and arbitrary large stand-off distance this metrology can be easily integrated in in-situ environments and is fully compatible with other optical metrologies such as thin film reflection spectroscopy, Raman spectroscopy or scattermetery. We also discuss application of low coherence interferometry for flatness and stress study. We demonstrate that this technology can be also applied in tress studies in low temperature environments without suffering complications inherent to other techniques. Furthermore we demonstrate that it is possible to obtain information about local stress using integrated metrology tool described above.

1. D. Huang, E. A. Swanson, C. P. Lin, J. S. Schuman, W. G. Stinson, W. Chang, M. R. Hee, T. Flotte, K. Gregory, C. A. Puliafito, J. G. Fujimoto, "Optical coherence tomography," Science 254, 1178-1181 (1991).

2. Wojciech Walecki, Frank Wei, Phuc Van, Kevin Lai, Tim Lee, SH Lau, and Ann Koo, “Interferometric Metrology for Thin and Ultra-Thin Compound Semiconductor Structures Mounted on Insulating Carriers”, CS Mantech Conference, May 3-6, 2004, Miami Beach, Florida

3. Wojciech J. Walecki, Frank Wei, Phuc Van, Kevin Lai, Tim Lee, SH Lau, and Ann Koo , "Novel Low Coherence Metrology for Nondestructive Characterization of High Aspect Ratio Micro-fabricated and

* [WojtekWalecki@frontiersemi.com](mailto:WojtekWalecki@frontiersemi.com); Tel: 1 408 452 8898; Fax: 1 408 452 8688

Micro-machined Structures", Reliability, Testing, and Characterisation of MEMS/MOEMS III, edited by Danelle M. Tanner, Rejeshuni Ramesham, Proceedings of SPIE Vol. 5343 p. 55-62 (SPIE, Bellingham, WA, 2004)

**TABLE 1: Repeatability of low coherence interferometric stress gauge**

| Wafer diameter [mm] | Wafer thickness [um] | Film thickness [A] | Bow/height change [um] | Radius of curvature1/R, [$m^{-1}$] | Stress, [$dyn/cm^2$] | Repeata-bility (1 x St Dev) |
|---|---|---|---|---|---|---|
| 200 | 725 | 6000 | 100 | 0.02000 | 5.26E+09 | 0.4% |
| 200 | 725 | 2000 | 10 | 0.00200 | 1.58E+09 | 3.5% |
| 300 | 775 | 2000 | 100 | 0.00889 | 8.01E+09 | 0.4% |
| 300 | 775 | 1000 | 10 | 0.00089 | 1.60E+09 | 3.5% |

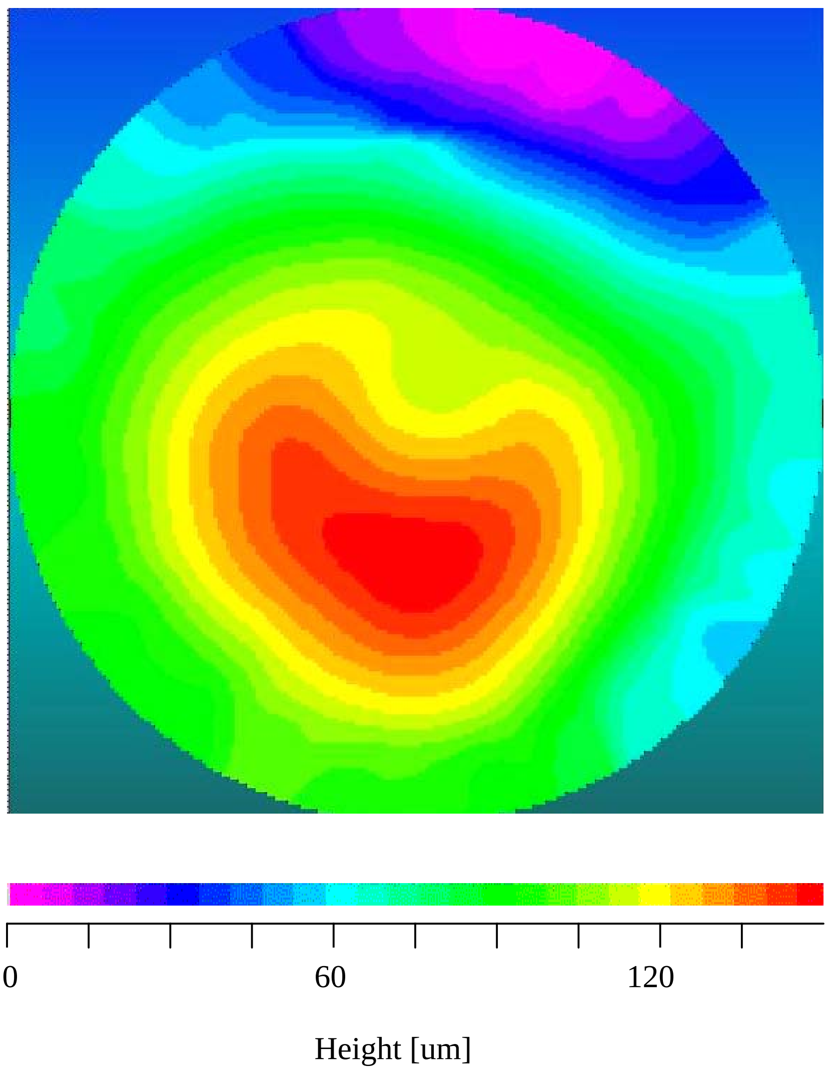


**Figure 1:** Topography of strained 300 mm diameter silicon wafer.