Instrumentation

Low-Cost Detection of Thin Film Stress during Fabrication

In-situ Measurement Using Fiber Optic Probes

NASA's Marshall Space Flight Center has developed a simple, cost-effective optical method for thin film stress measurements during growth and/or subsequent annealing processes. Stress arising in thin film fabrication presents production challenges for electronic devices, sensors, and optical coatings; it can lead to substrate distortion and deformation, impacting the performance of thin film products.

NASA's technique measures in-situ stress using a simple, noncontact fiber optic probe in the thin film vacuum deposition chamber. This enables real-time monitoring of stress during the fabrication process and allows for efficient control of deposition process parameters. By modifying process parameters in real time during fabrication, thin film stress can be optimized or controlled, improving thin film product performance.

BENEFITS

- **Low-cost, simple design**—Uses inexpensive off-the-shelf fiber optic probes, reducing costs by an order of magnitude or more
- **Real-time measurement**—Provides immediate feedback via in-situ probes, facilitating the efficient adjustment of deposition process parameters
- **Easy to implement**—Requires little or no modification to the existing vacuum chamber
- **Versatile**—Applies to a wide range of thin film and bulk material applications
- **Sensitive**—Offers sensitivity of 0.05 N/m, comparable to existing techniques, such as the multibeam optical stress sensor (MOSS)

technology solution

THE TECHNOLOGY

Traditional methods of determining film stress use ex-situ deflectometry techniques and require significant and costly modifications to the vacuum chamber to allow optical access to the substrate. These techniques determine film stress by measuring the change in substrate curvature resulting from stress.

NASA's method infers the stress-induced substrate curvature by measuring the out-of-plane displacement of a single point on the substrate using a fiber optic displacement sensor (Figure 1). The probe gains optical access to the substrate through a normal fiber optic feedthrough common in vacuum systems. In turn, this simplification leads to a significant reduction in cost, complexity, and system requirements. It also eliminates interference effects, which can occur when measuring the stress in transparent films found in other techniques. With a measurement sensitivity of 0.05 N/m, the method is comparable in sensitivity with MOSS and could potentially rival the sensitivity of the microcantilever technique.

NASA's method embodies the ability to measure the stress during film growth for heated substrates, as well as the evolution of stress during thermal annealing processes. The technique is versatile and can be used in a variety of thin film applications, with no limitation on substrate size or reflective characteristics of deposited films. The methodology has been proven with magnetron sputtering of chromium films, where it was used to adjust process gas pressure to achieve zero stress.

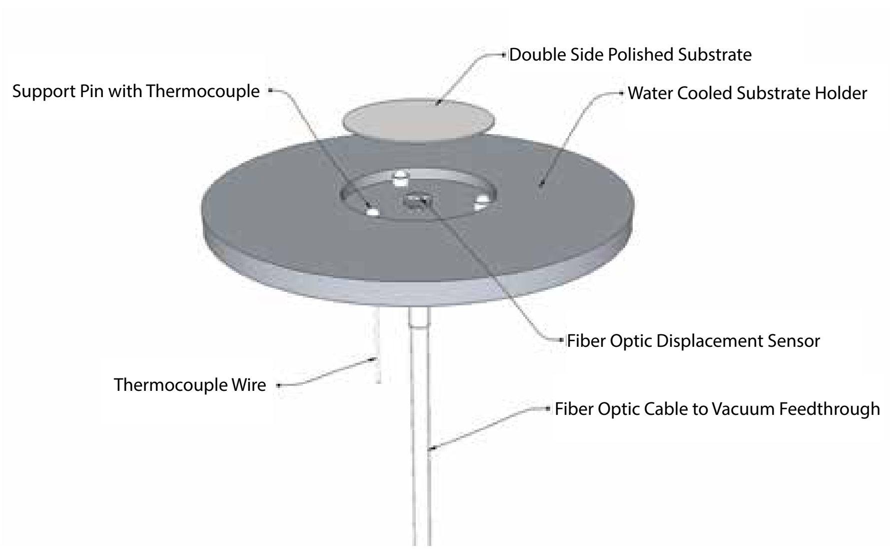


FIGURE 1 – The NASA technique determines thin film stress using an in-situ fiber optic displacement sensor.

APPLICATIONS

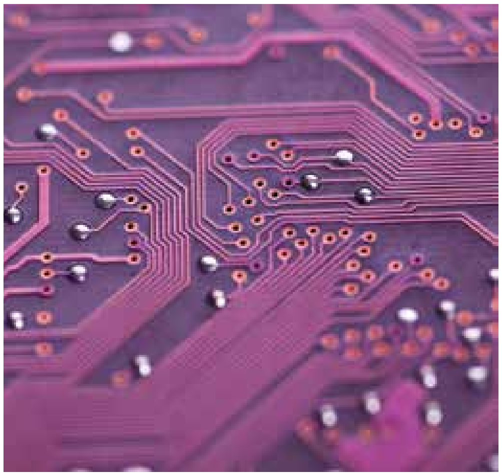
The technology offers wide-ranging market applications, including:

Semiconductors – Electronic devices; solar cells; printed circuit boards

Optics – Coatings

Magnetics—Read/write heads

Precision machining—Metrology of surfaces; surface plates



More Information

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