Newport Motion Advancing
Ultrafast Photoacoustic Spectroscopy for Thin Film Metrology

Ultrafast Photoacoustic characterization is a spectroscopic technique that exploits the photoacoustic effect and ultra-fast laser technology to study materials at the nanometer scale. A Newport customer in France is using this technique to provide metrology services to thin film researchers in the scientific community and semiconductor marketplace. The photoacoustic effect is an astonishing accomplishment of science. It relies on incident light to cause local thermal excitations in a sample which then creates acoustic waves. This technique has been advancing with the development of ultrafast spectroscopy in recent years.

When an ultrafast laser pulse is directed at a highly absorbing target, the entire pulse energy is absorbed by a thin surface layer of just a few nanometers, resulting in intense local heating. If the material is a metal, the interface layer will undergo rapid expansion, creating a high frequency acoustic shock wave. Researchers realized that these photo-duced acoustic waves could be used to perform Sound Navigation and Ranging (SONAR) with a dramatically improved spatial/temporal resolution. For example, layer thickness in integrated circuits can be determined by the time delay of the returning acoustic echo from the interfaces between material layers.

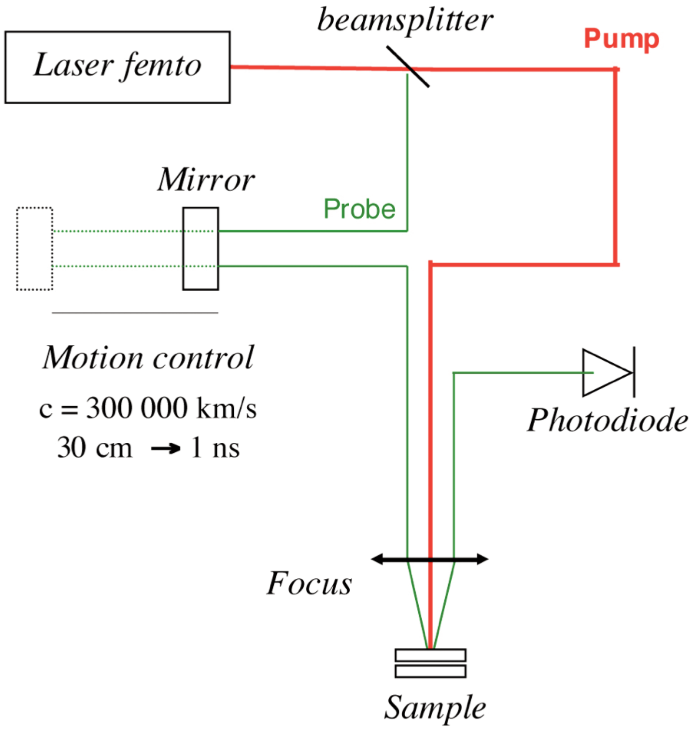

Fig. 1: Schematic of Ultrafast Photo-acoustics Experimental Setup

The schematic diagram of an experimental setup (Fig 1) illustrates how an echo pulse is detected using a conventional pump-probe setup. The input laser pulse is split into a pump and a probe pulse, the latter passing through a variable delay line. When the acoustic echo passes through the outer metal layer, it strains the electronic structure of the lattice, thereby perturbing the refractive index of the metal and changing its reflectivity. This is detected as a function of pump-probe delay. Alternatively, if the material is coated with a transparent outer layer, the probe pulse interacts with this layer like a very thin Fabry-Perot etalon, where the reflected intensity is a result of interference between the front and rear surface reflections.

Fig. 2: Newport motorized stage used in an optical delay line

The probe pulse is delayed with respect to the pump pulse with an optical delay line technique. In the optical delay line experiment, a reliable mechanical stage with sub-micron resolution and high accuracy is critical in order to precisely control the pulse delay. Newport M-IMS600LM High Performance Linear Stage meets all the requirements of the application, offering superior accuracy over the 600mm travel distance. As the photo-induced sample excitation occurs on the femto to nanosecond scale before generating the acoustic wave, electronics triggering and synchronization become critical in the process. For this reason, an ability to send an external trigger signal based on position provides an added benefit for time-resolved experiments. The Newport XPS Universal Motion Controller features the Position Compare Output (PCO) for the precise triggering of external devices with the extremely low latency of 50 ns.

The team of researchers in the thin film metrology application was able to make a key discovery on detection techniques that are sensitive to the wavelength of ultrafast lasers. With Newport motion solution and the innovative detection technique, Ultrafast Photoacoustic technology continues its advancement today at the intersection of Ultrafast lasers, Acoustics and Optics.

To learn more about Newport product offerings for optical delay line applications, please contact Newport sales and applications engineers.

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