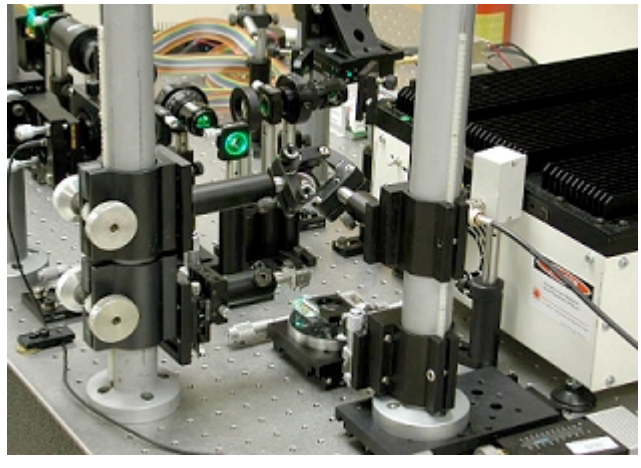
# LASAW-NC - Introduction and Theory of Operation

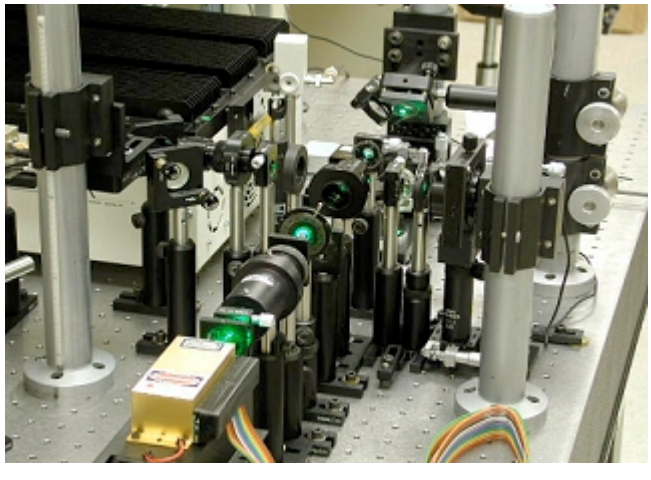
## *How it works….*

A short-duration laser pulse (1-2ns) is applied to the surface of the material to be tested. This laser pulse generates surface acoustic waves (phonon waves) of a range of frequencies that propagate laterally through the material outward from the laser pulse. The acoustic wave looses energy to the material as it propagates – disperses through the material. The velocity of the material is dependent upon the frequency of the acoustic wave. This relates to film properties in several ways. The higher the frequency of the acoustic wave, the closer to the surface the wave propagates. The mismatch between waves propagating at different frequencies at varying depths in the sample indicates the mechanical properties of both film and substrate material.

## *Capabilities….*

- Measures thickness, hardness, elasticity, and poisson's ratio
- Non-destructive, non-contact measurement
- Measure film thickness – 5nm to near bulk
- Metals, dielectrics, ceramics, polymers
- Fast measurement time – 5-10 minutes
- Easy operation





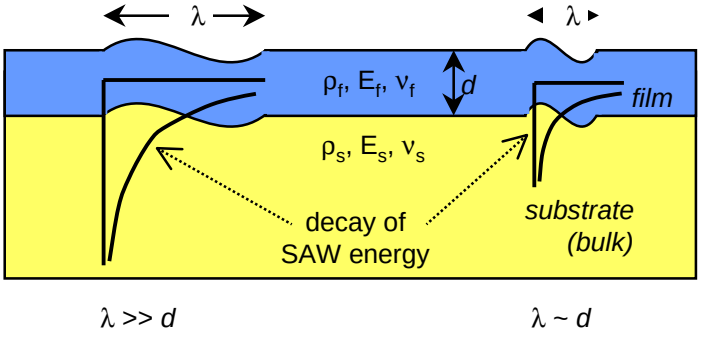
## *Features….*

- Laser generated pulse – 1-2ns duration
- SAW frequency 50-250MHz
- Optical detection – no contact with sample surface
- Out of plane displacement
- Path-stabilized for signal averaging
- Automated translation/rotation with encoder readout
- Photo-receiver detection frequency – up to 800 Mhz
- Oscilloscope – up to 2 Ghz

# Surface Acoustic Waves

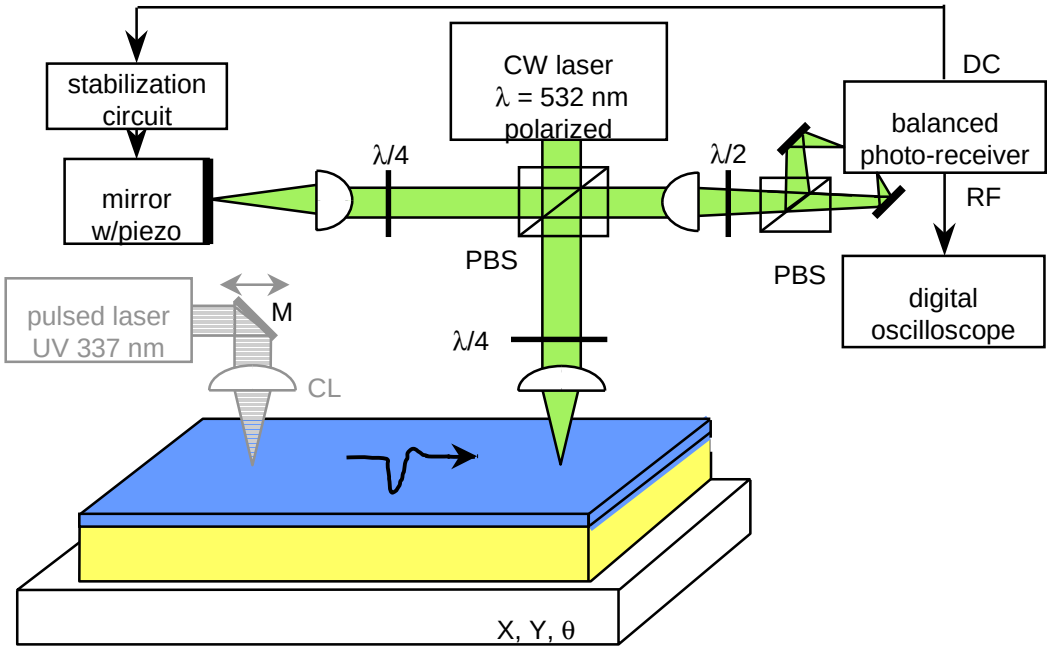
**dispersion:**

**Dispersion of SAW in material**



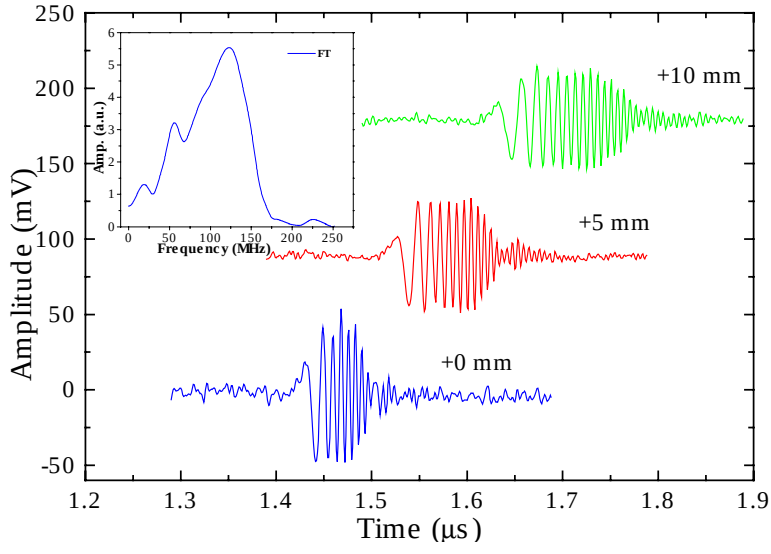

- SAW energy decreases exponentially away from surface
- displacements parallel and perpendicular to *k*
- Wave velocity *v* depends on frequency *f* (wavelength λ)
- *v* depends on wavelength λ relative to thickness *d*
- longer λ: *v* depends mostly on substrate properties
- smaller λ: *v* depends more on film properties

**Michelson Interferometer for SAW Detection**



# Optically-detected SAWs and dispersions - Examples

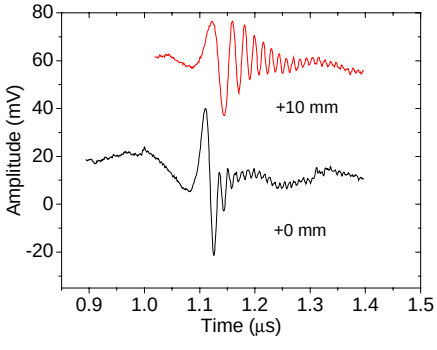
**SAW waveforms**
⇓
**FFT**
⇓
**phase difference**
⇓
**velocity dispersion curve**



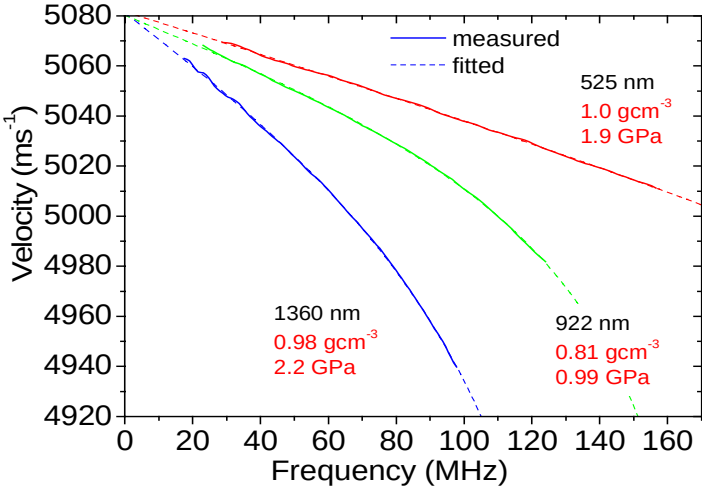

**666 nm Aerogel on Si**

**FFT of wave-packets yields velocity dispersion curve shape dictated by elastic parameters:**

Fit ρ and E




FFT




**SAWs on 1360 nm porous SiLK film**

**Measured Dispersion curves on porous polymer samples (MSSQ) (Silicon (001), [110])**

*Applications….*

- Semiconductor materials
- Flat-panel displays
- Optical and photonics device materials
- Storage media (hard disk drives, DVD)
- Industrial – hard, wear resistant, and thermal barrier coatings
- Nano-material development