UPGRADE OPTIONS

Acoustic Emission Monitoring

In-Situ Acoustic Emission Testing with Quasistatic Indentation

The unique capabilities of *in-situ* acoustic emission monitoring during quasistatic nanoindentation have proved invaluable in understanding the failure mechanics of brittle materials. This is possible using a specially designed transducer and tip which incorporates an acoustic emission sensor in addition to the Hysitron load and displacement measurement capabilities.

During the nanoindentation a force is applied by the transducer and the resulting displacement is observed to produce a traditional force verses displacement curve (figure 1). In addition to this any crack-induced release of elastic strain energy stored at the local contact between the indenter and sample can be simultaneously measured acoustically as shown in figure 2.

The unique capabilities of the acoustic emission package is brought about due to the signal being measured at the tip. this creates an extremely sensitive detection system capable of sensing very small AE signals. Due to the AE sensor being mechanically coupled to the sample through the tip, the system is sample size independent meaning small structures and devices can be measured.

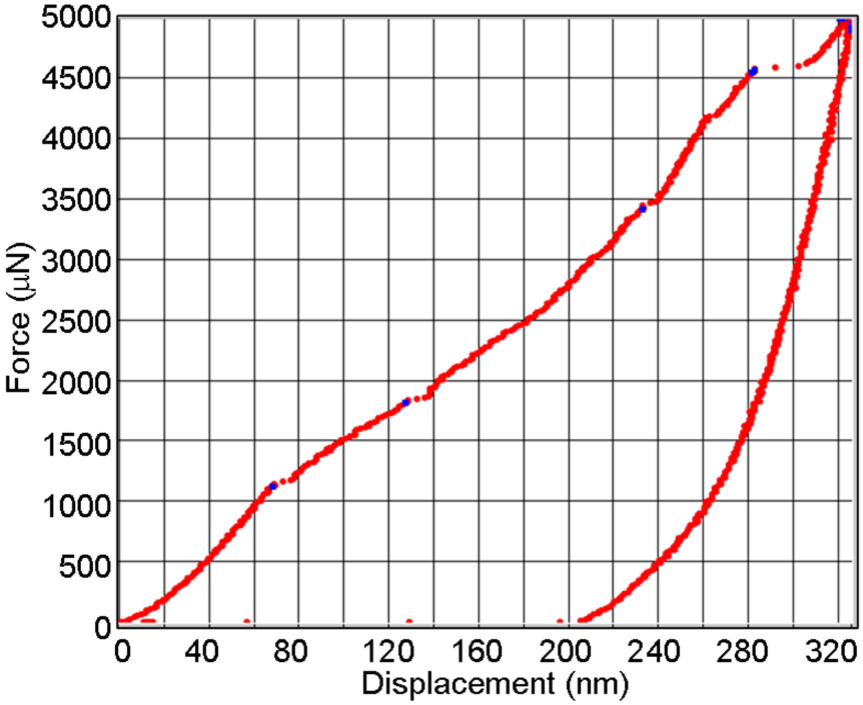

Figure 1. Quasistatic nanoindentation curve correlated with acoustic emission events which are indicated by blue dots.

Figure 1 shows a load displacement curve from quasistatic nanoindentation of an amorphous diamond film on silicon. Blue points indicate acoustic emision measurements during the test. These acoustic emission events were detected with increasing load, and correspond to the yield point of the coating, sinking-in phenomena, interface fracture and tip adhesion, respectively.

Frequency and time domain data as well as distribution of amplitudes can be easily plotted for statistical analysis.

Acoustic waveforms such as those shown in figure 2 are processed using bandpass wavelet filtering.

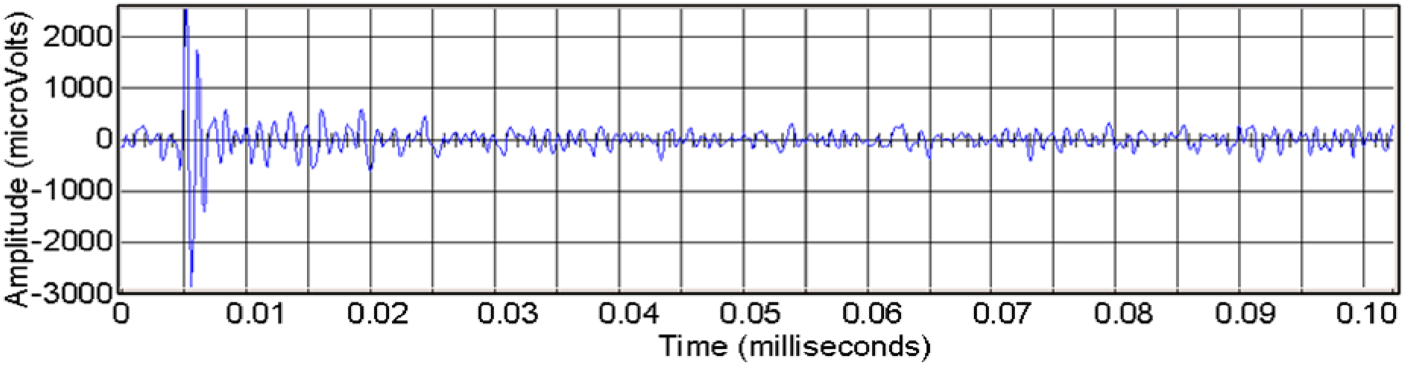

Figure 2. Plot of amplitude of acoustic event which occurred during first event on load displacement curve in figure 1.

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Analyzing Acoustic Emission Data

All Hysitron nanoindentation systems come standard with *in-situ* SPM imaging. Using the same probe to scan a sample surface immediately before and/or after a test allows for precise placement of the test as well as near-instant observation of events or sample recovery. The importance of this is shown in figure 3 where the amorphous diamond film has been imaged after indentation testing and showing obvious signs of fracture. The lengths of the cracks can be measured and the fracture toughness K_{IC} can be calculated and correlated to the acoustic emission data.

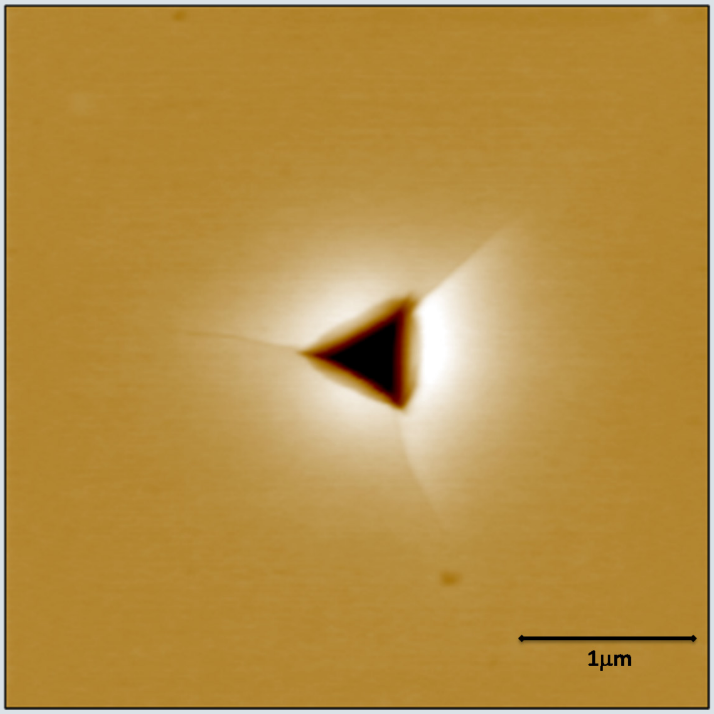

Figure 3. SPM image of amorphous diamond film after quasistatic indentation showing fracture events in the form of crack propagation from the corners of the indent tip. These areas are known to have high stress concentrations during indentation.

The variance in the standard deviation is illustrated in figure 4, and can be plotted easily using the custom designed software, included in the acoustic emission package.

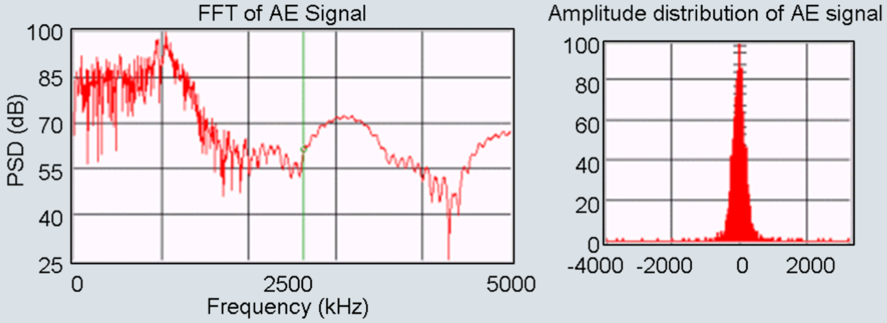

Figure 4. Frequency domain data and distribution of amplitude for acoustic second event occuring in figure 1.

HIGHLIGHTS

- Generated elastic and surface acoustic waves were monitored by the specially designed acoustic emissions sensor integrated into Hysitron indenter tip
- Non-destructive testing provides quantifiable data for material testing
- Custom designed software to aid in statistical analysis and time and frequency domain calculations
- *In-situ* SPM imaging provides imaging of the tested location, essential for calculation of fracture toughness

APPLICATIONS

- Relevant to all materials subject to brittle failure including:
    - Ceramics
    - Thin Films
    - Composites
    - Glasses