C13 3D Characterization and Comparison of Fracture Surfaces

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After attending this presentation, attendees will become familiar with fracture characteristics from materials and fracture events.

This presentation will impact the forensic science community by answering the National Academy of Sciences (NAS) call in the area of fracture surface matching where traditional matching techniques become limited when macroscopic surface features are degraded, and to incorporate an engineering technique.

In 2010, according to the FBI's Uniform Crime Report, over 150,000 violent crimes were reported to have a knife or other sharp, cutting instrument involved. Conclusively matching two halves of a fracture surface can be crucial to a criminal investigation. For example, if a knife tip is found at a crime scene, proving that it belongs to the suspect's knife depends upon the expert opinion of the forensic examiner. At present, a visual pattern match of the two surfaces is the most common way to match fractured pieces. The 2009 National Academy of Sciences Report, *Strengthening Forensic Science in the United States: A Path Forward* calls for reforms and major changes to current forensic science practices. The goal of this project was to answer this call in the area of fracture surface matching where traditional matching techniques become limited when macroscopic surface features are degraded, and to incorporate an engineering technique with mathematically and statistically defendable error rates to fill this gap.

The goal of this study was to determine whether surface measurements could be used to conclusively associate two fracture surfaces. With the use of instrumentation (Direct White Light Interferometry (DWLI), Scanning Electron Microscopy, and Optical Microscopy), micron level measurements were gathered from the fracture surfaces of both the knife tip and the suspect knife. The measurements would then be used to compare the two fracture surfaces and determine if they were from the same fracture event. This new method seeks to assist the examiner by providing mathematical support for an exclusion, identification, or inconclusive determination concerning the tip and suspect knife.

In order to achieve this, a two-inch section from each knife in a set of was broken off. Each knife now consists of a tip and a base. For the experiments, each knife base was assigned a random code consisting of a letter followed by two numbers to differentiate this set of samples from others. The samples were all examined and matched to the other half using an optical microscope simulating conventional forensic fracture matching.

Direct White Light Interferometry was utilized to scan the samples in three predetermined zones of the fracture surfaces. Fast Fourier Transform algorithms were used to process the topographical surface feature data to convert the data into distinct average frequencies for each surface. An algorithm was used to compare the average frequencies of each surface pre- and post-exposure to delineate match results.

The fracture surface topography measurements were collected using the DWLI. To capture the range of surface features, a magnification of 20x was chosen. The field of view at this magnification of 20X is 0.55mm by 0.55mm, representing only a portion of the entire surface during the DWLI scan. To obtain an accurate representation of each fracture surface, three scans are taken, each in a different region of the fracture surface. The DWLI records the scan in nanometers, and the output is a three-column matrix, where the first two columns designate the pixel and the third column is the height at that pixel.

The matrix is run through an algorithm which uses the Fourier Transform to compare the mean frequency of each fracture surface. The difference between the mean frequency of two fracture surfaces indicates if the surfaces are a match or not. With the narrow height range parameters used to measure the fracture surfaces on the instrumentation, the software is used to discriminate between samples. Comparisons of fracture surface feature frequencies between samples will be discussed in terms of a quality of match for a known match versus non matches.

Fracture, Steel, Interferometry

 ** Presenting Author*