Microstructural Characterization of Ti-6Al-4V using Acoustic Emission Signals During Nanoscratch Test

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Introduction
- Known techniques to observe microstructures involve imaging the surface using electron or optical microscopy, spectroscopy, or nanoindentation.
- We study an automated approach to characterize microstructures in-situ using nanoindentation setup without imaging the surface.
- Detect microstructures using an acoustic emission (AE) sensor to capture changes in acoustic waves emitted by the indenter tip that correspond to the needle grazing grain boundaries.

Intrinsic Time-Scale Decomposition
- The original signal is decomposed into a proper rotation, and residual signal called the baseline\textsuperscript{[1]}. The procedure is reapplied to the baseline signal to obtain a monotonic trend.
- Stops when the resulting baseline has only two extrema or is a constant\textsuperscript{[2]}.

Experimental Procedure
Nanoscratch setup:
- Hysitron Ti 950 TriboIndenter
- Loading and unloading time of 5 s, actual scratch 17 s
- Down force of 800 μN collected at 500,000 Hz
- Down force of 10,000 μN collected at 100,000 Hz
- Sensor on the surface of the sample

Results
Red line indicates indenter starting and stopping, orange highlight indicates loading and unloading, blue highlight indicates actual scratch.
- No trends or patterns are visible in original signal.
- No consistent patterns in changes during load or unload, they may increase, flat line, or spike.
- Changes during scratch are random and do not match scratch in surface image.
- Baseline signal in Fig 5. shows no change between loading and scratch.
- Changes are present between the indenter operating and not, but have no consistent pattern or trend.

Conclusions
- AE sensor can be used to detect changes in the signal that occur when loading and unloading start and end, and scratches start and end.
- No consistent pattern exists among the changes, thus they are inconclusive.
- Distinct changes present in the middle of the scratch and load are random and inconclusive to whether these changes are indicative of the indentation tip grazing over grain boundaries.
- The proposed approach cannot be automated with a nanoindentation setup using this external AE sensor. A more sensitive sensor is necessary.

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