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.

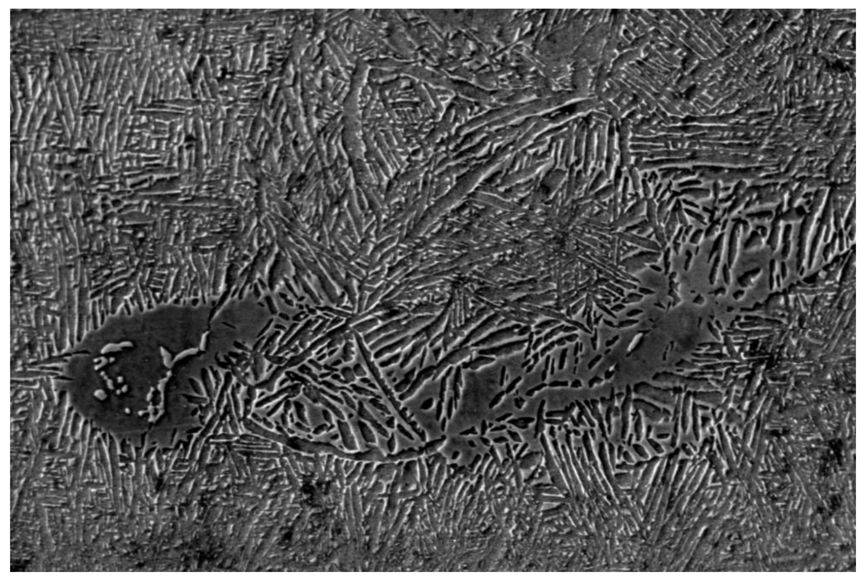

Fig 1. Microstructures on workpiece, image processed using Scanning Electron Microscope (SEM)

Intrinsic Time-Scale Decomposition

- The original signal is decomposed into a proper rotation, and residual signal called the baseline[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[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.

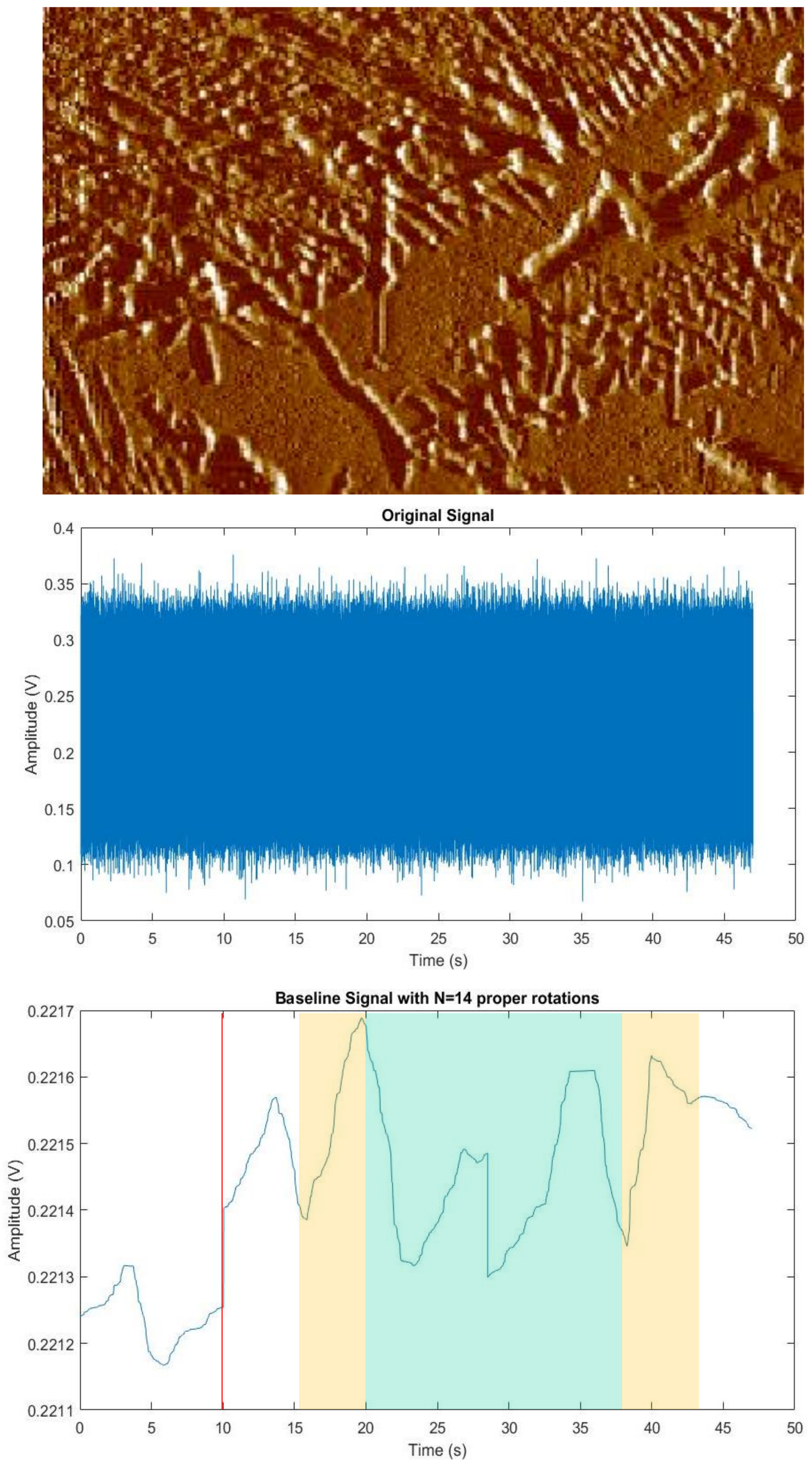

Fig 2. Surface image of 10 µm nanoscratch with corresponding signal captured before, during and after scratch collected at 500 kHz with 800 µN maximum down force.

- 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.

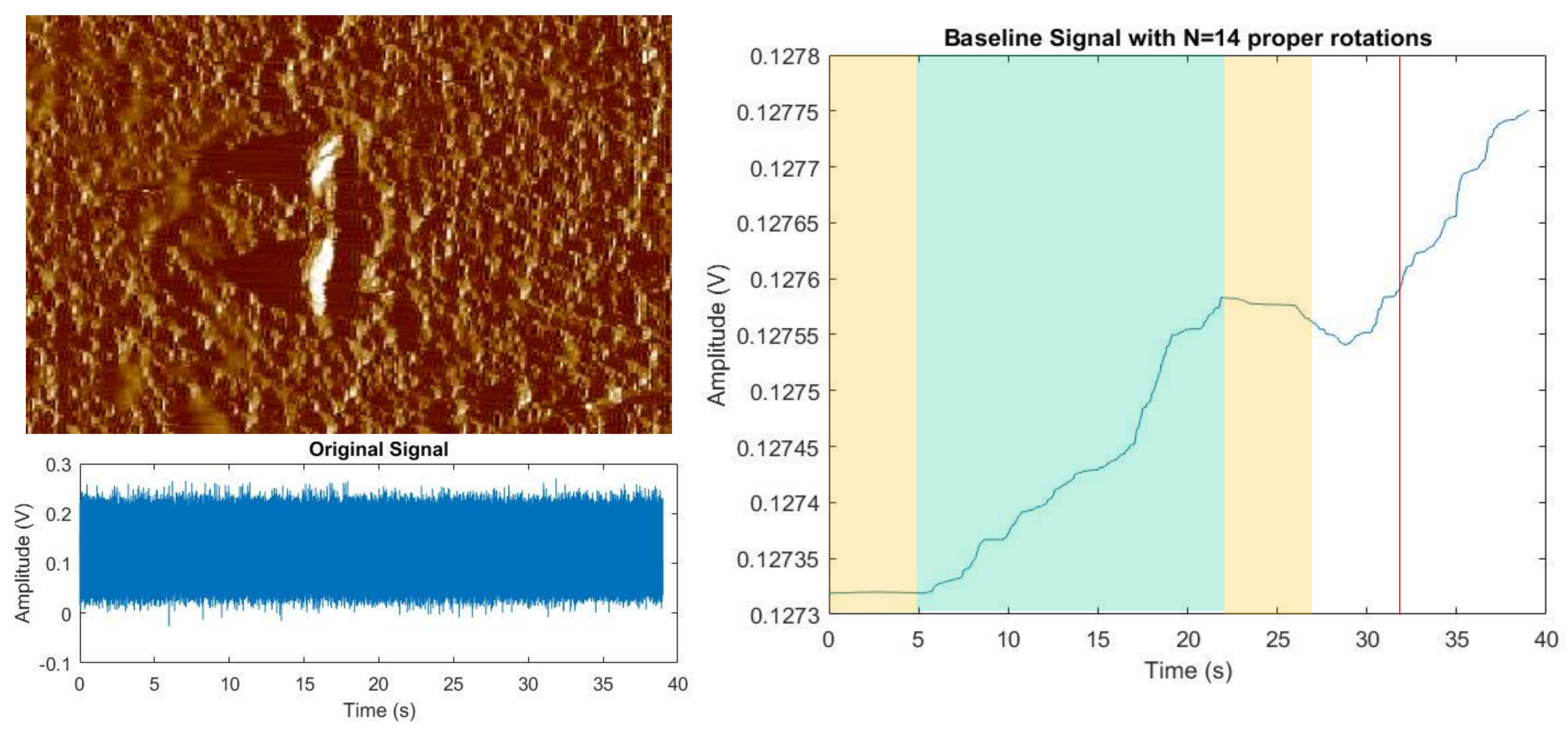

Fig 3. Surface image of 10 µm nanoscratch with corresponding signal captured during and after scratch collected at 100 kHz with 10,000 µN maximum down force.

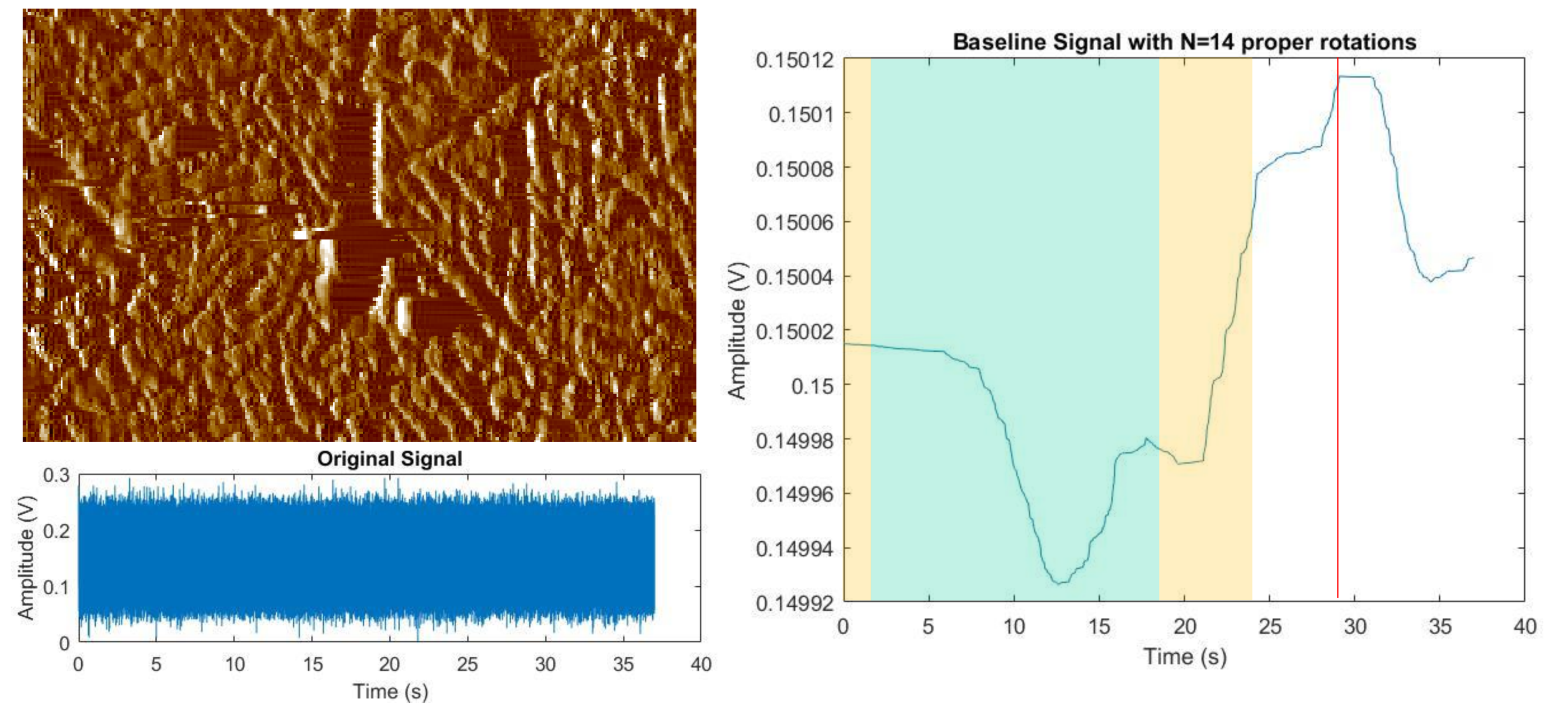

Fig 4. Surface image of 10 µm nanoscratch with corresponding signal captured during and after scratch collected at 100 kHz with 10,000 µN maximum down force.

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.

Acknowledgments

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References

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