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Grain-boundary Scattering of Surface Acoustic Waves: Experiment and Simulation

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Grain-boundary scattering is the major contribution to acoustic-wave attenuation in common polycrystalline materials at ultrasonic frequencies. A number of studies in the recent years showed that the two-point correlation function (TPCF) of the microstructure plays a vital role in the resulting frequency-dependent attenuation of bulk waves.[1] However, the topic of surface acoustic waves (SAWs) remained more or less untouched.

This contribution aims to fill this gap and shows a comprehensive study of the SAW behavior in polycrystals: First, the frequency-dispersion of the SAW attenuation in a polycrystalline aluminum sample was studied experimentally using a frequency-domain laser-ultrasonic setup.[2] Then, a statistical digital twin of the sample was created based on the TPCF similarity using a Laguerre tessellation. Such a digital twin was then used for a time-domain FEM simulation of SAW propagation.[3] The results of such a virtual experiment are in good agreement with the experiment itself in a broad range of frequencies in the stochastic regime of scattering, showing a large potential of the concept of virtual experiment with TPCF-based digital twin. The results also suggest that the power-law exponent of $\alpha \propto f^n$ in the stochastic regime is lower for SAW than it is for bulk waves.

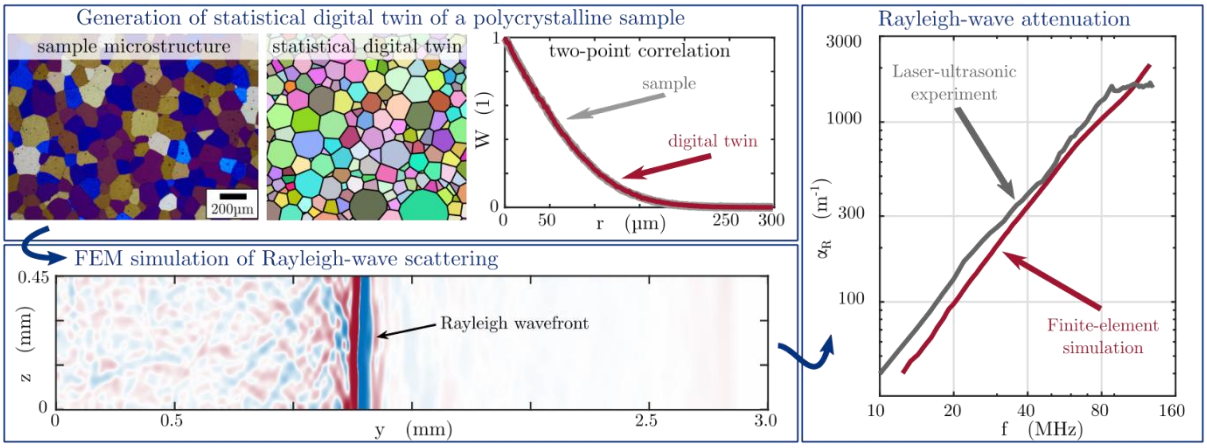

Figure: The relation of the sample and its statistical digital twin (top left), the out-of-plane displacement in the FEM simulation of SAW propagation through the digital twin (bottom left), comparison of resulting frequency-dependent attenuation in the simulation and experiment discussed in [1]. [3]

References

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