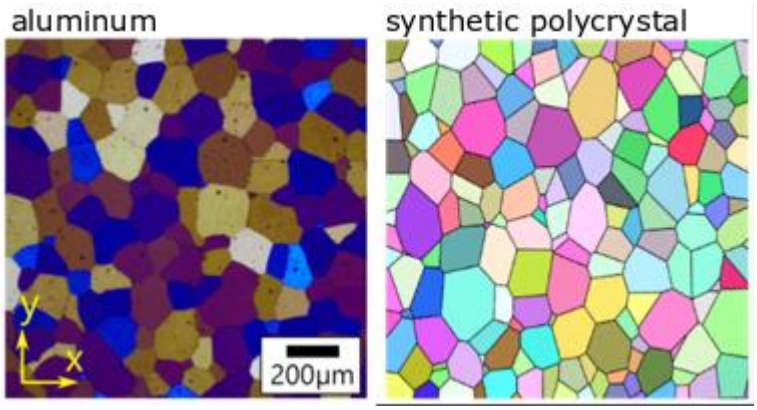
SUCCESS STORY

PSSP
Photonic Sensing for Smarter Processes

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Project

Duration: 2018 - 2022



Real microstructure of aluminum (left) and computer generated grain structure (right) with grain-sizes of approximately 100µm. © RECENDT GmbH

THE SOUND OF METALS: ULTRASOUND FOR MICRO-STRUCTURE-CHARACTERISATION

THE IDEA OF USING ULTRASONIC WAVES FOR GRAIN STRUCTURE ANALYSIS IS AS OLD AS THIS METHOD ITSELF, BUT IT STILL FACES UNSOLVED PROBLEMS. WITH OPTICAL MEASUREMENT METHODS FOR SURFACE WAVES AND NEW 3D SIMULATIONS, AN IMPORTANT STEP FORWARD HAS BEEN ACHIEVED.

Metals have an internal grain structure, which significantly determines their mechanical properties. In order to produce materials with tailor-made properties efficiently, it is highly important to determine their grain size as accurately as possible – preferably directly during production processes. Since the attenuation of acoustic waves is also influenced by the grain structure, the mean grain size can be determined - at least theoretically - by measuring the acoustic attenuation and then comparing it with a theoretical model.

Laser-based ultrasound is a particularly elegant method for excitation and measurement of acoustic waves. Furthermore, the technology is contactless and thus also well applicable in the rather rough industrial environment. By using Laser-Ultrasound, a researcher at RECENDT in Linz was already able to determine the effective attenuation of surface acoustic waves (the counterpart, when talking about solid matter, to water waves in fluids) in aluminum in a very wide frequency range during his PhD-thesis.

However, comparison with theoretical predictions showed quite weak agreement, too inaccurate to use this theoretical model for the practical determination of grain size.

Federal Ministry Republic of Austria Transport, Innovation and Technology

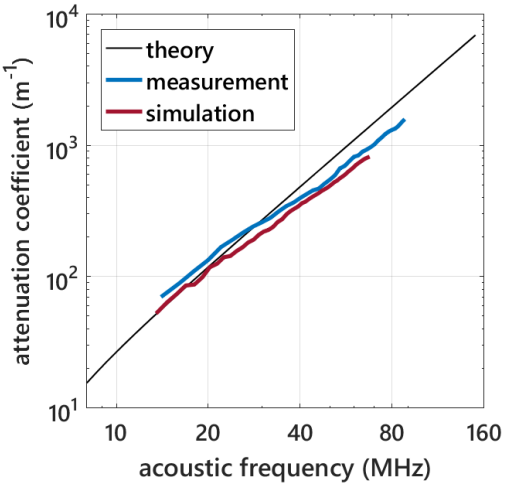
Federal Ministry Republic of Austria Digital and Economic Affairs

Version 01/2019

Impact and effects

In the K-Project PSSP, where this work is being continued, an important step towards applicability has now been taken: In cooperation with a research group from Prague, a model (a "digital copy") of the investigated sample was produced, which has the same statistical properties as the real material itself (see figure on page 1). To put it simply, this means that the grains in the "digital twin" do not look exactly the same as in the real sample, but on average have about the same size. Wave propagation was then simulated by means of a complex 3D computer simulation using the finite element method (FEM). From that, the effective acoustic attenuation was determined.

The agreement with the measured attenuation is now suddenly impressively good (see figure on the top right). This suggests that the measurement method is extremely accurate and that the previous differences between measurement and theory can be attributed to the imprecise theoretical model. In future work, the theoretical model will be refined, in order to be usable for grain size calculations from measured attenuation curves.



The curves for measurement and simulation show the good agreement that was achieved with the new simulation and measurement technology. © RECENDT GmbH

The work in PSSP has thus shown a new and reliable method for the determination of the grain-size of common engineering metals, which will be developed further to be directly applicable during industrial production processes.

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This success story was provided by the consortium leader/centre management and by the mentioned project partners for the purpose of being published on the FFG website. Further information on COMET: www.ffg.at/comet

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