Damping of vibrations of a rod by dissipation due to diffusion

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The Thermodynamic Extremal Principle (TEP) [1] represents an excellent tool for thermodynamic modeling of microstructure evolution controlled by diffusion and/or by interface mobility. In a standard way, such models are based on solution of partial differential equations with respective starting, boundary and contact conditions. Then the evolution of the system microstructure can be described by kinetics of characteristic paraments extracted from the solution of the differential equations. This way is, however, often rather complicated and can be significantly simplified by using the TEP. In that case, we can select the most appropriate characteristic parameters for the microstructure evolution and use the TEP to derive the evolution equations for them without the need to solve the partial differential equations. The method of TEP is demonstrated on the following example.
Understanding the interaction of vibrations with diffusion, e.g. of carbon in fcc lattice, is still of practical relevance. An analytical framework is offered based on the mechanics and thermodynamics, where the evaluated total dissipation by diffusion allows calculation of damping of a vibrating rod from the Gibbs energy balance. Finally, a simple relation is found relating the diffusion coefficient, geometry and elastic properties of the rod with its damping coefficient. This method could be utilized for measurement of the diffusion coefficient. More details can be found in [2].

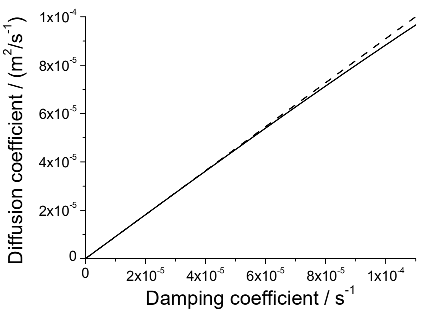

Fig. 1. Diffusion coefficient *D* calculated versus to the damping coefficient *q* according to Eq. (18) (solid) and to Eq. (19) (dashed).

References

[1] Fischer F.D., Svoboda J., Petryk H.: Thermodynamic extremal principles for irreversible processes in materials science. Acta Mater. 67 (2014) 1-20.
[2] Svoboda J., Hackl K., Fischer F.D.: Damping of vibrations of a rod by dissipation due to diffusion. Scripta Materialia 257 (2025) 116461.