# A coupled multiphase-field and carbon diffusion model for lower bainitic transformation

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## ABSTRACT

The lower bainitic transformation is one of the most complex transformations in steel. The transformation from austenite to bainitic ferrite is assumed to be displacive [1] in contrast to the perlitic growth which is highly dependent on the carbon movement and therefore is ranked as a diffusive transformation. However regarding the whole microstructure named bainite, consisting of bainitic ferrite, carbides and (residual) austenite, the movement of the carbon is of great importance. The displacive growth of the bainitic ferrite leads to a supersaturated phase. In lower bainite the carbon within the ferrite separates [1] and precipitates as carbides. Furthermore some carbon atoms succeed in leaving the ferrite and enrich the carbon concentration of the surrounding austenite. This may lead to carbides close to the interface between ferrite and austenite but may also stop the transformation from austenite to bainitic ferrite and produce residual austenite.

In this work the phase-field method, widely used in material science, is utilized to simulate the phase transformations from austenite to bainitic ferrite and the precipitation of carbides [2]. The phase-field method is coupled to a diffusion equation governing the carbon concentration. The underlying system of partial differential equations is based on a thermodynamic framework of generalized stresses as introduced by Gurtin and Fried [4, 5] for a two phase Ginzburg-Landau system and a Cahn-Hilliard equation. We extend this framework for multiphase-field models coupled to a viscous Cahn-Hilliard equation [3] as it is needed for the lower bainitic transformation. The key aspects of the thermodynamic framework are generalized stresses and microforces which perform work in conjunction with derivatives of the phase-field variables and the carbon concentration. The framework distinguishes between basic balance laws which are universal and constitutive equations which depend on the specific material. The Clausius-Duhem inequality is used to impose restrictions to the constitutive equations. The numerical examples show the qualitativ mechanism of the lower bainitic transformation as discussed above.

## REFERENCES

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