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A numerical study of heterogeneous annealing in a finite one-dimensional geometry

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The irradiation of a material with high-energy particles causes the formation of different types of defects in its crystalline lattice. At any temperature above absolute zero, the defects anneal spontaneously and the rate of annealing increases with temperature. The thermal energy released in the process of annealing contributes to the temperature of the material, and creates a positive feedback effect referred to as the thermal-concentration feedback. The non-homogeneous distribution of defects or of temperature in the material, along with the thermal-concentration feedback, may lead to the appearance of a self-sustaining annealing wave. Conditions for the formation of the annealing wave are currently not well established. In this study numerical modelling of the heterogeneous annealing in a finite one-dimensional geometry was performed. To this end, a finite difference solver was implemented, verified and applied in our numerical experiments. The self-sustaining annealing process was initialized by adding heat to a localized region near the material surface at the initial moment. Evolution of temperature and defect distributions during the process of annealing was obtained for different initiating heat distributions and initial defect concentrations. It was demonstrated that for large values of initiating energy, the annealing process develops as a wave, which propagates at a constant speed. For more moderate values of initiating energy, the interplay of the heterogeneous initial heat distribution and the spontaneous annealing leads to the appearance of the wave regime in the terminal part of the process.

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