Mass transfer and atoms mobility in high-entropy alloy and steel under the force influence

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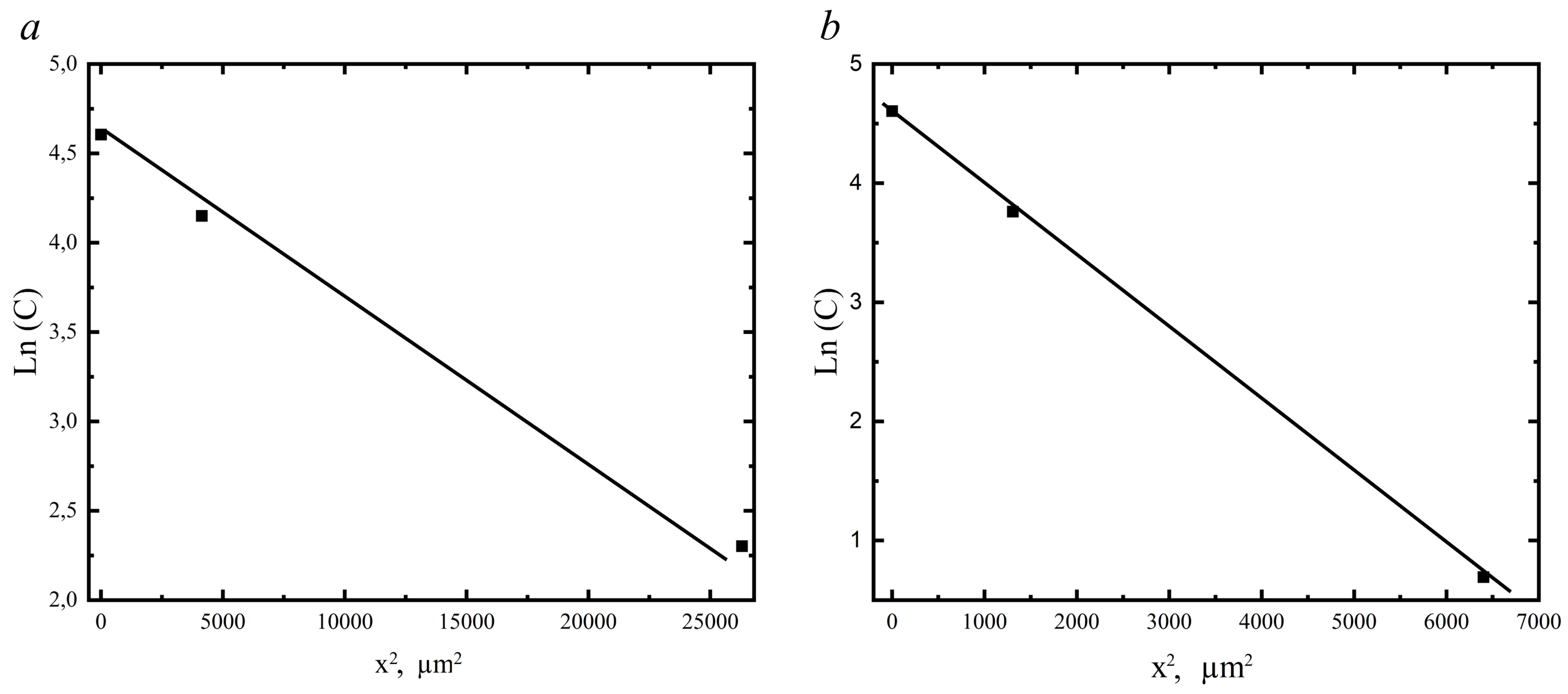
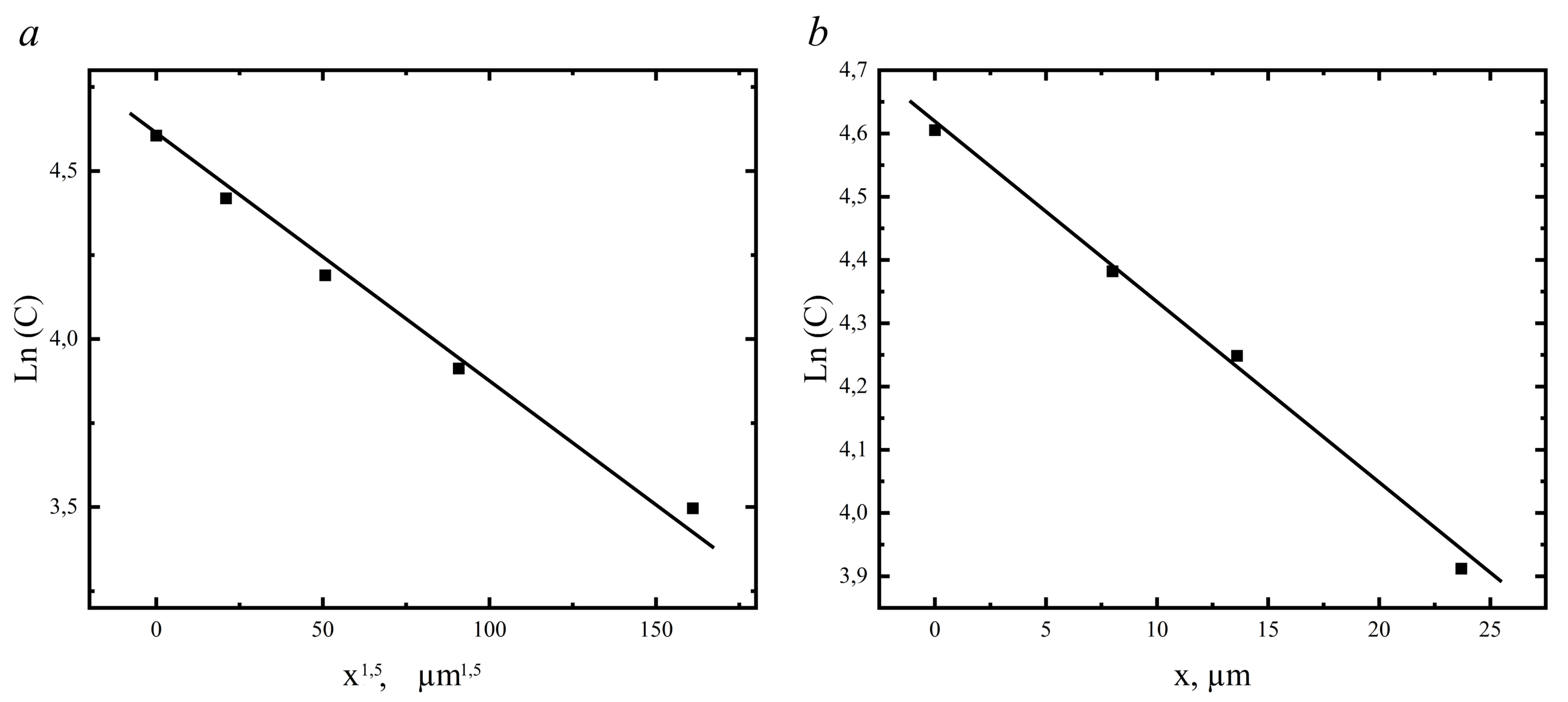
Introduction

In this work, an experimental approach has been developed to determine the parameters of anomalous mass transfer by the method of radioactive isotopes using ^{60}Co as applied to HEA (AlFeNiCoCuCr) and steel 3 after electro-spark alloying and shock treatment.



Graph of the dependence: a) - for steel 3 after ESA; b) - for HEA ***after ESA.***



Graph of the dependence: a) for Steel 3 after impact; b) for HEA ***after impact.***

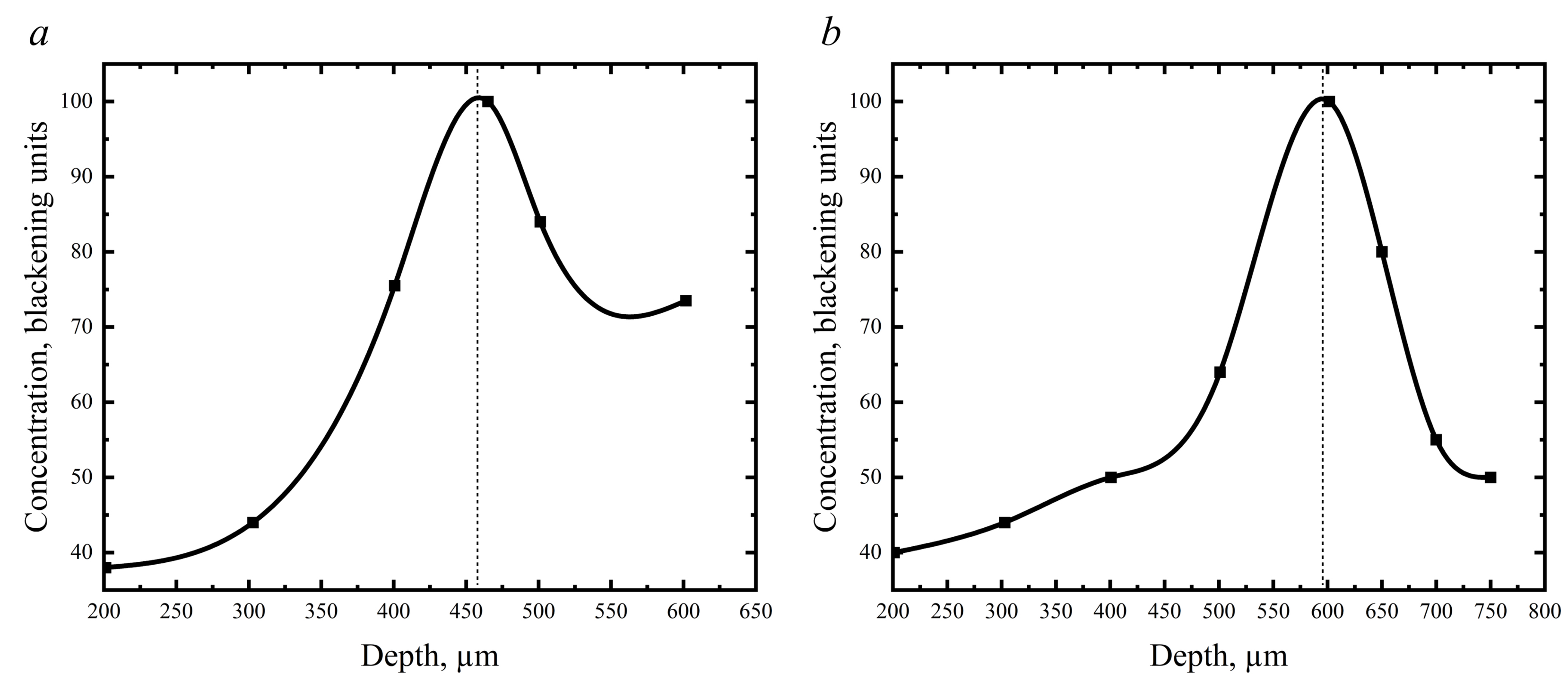
Results and discussion

A graph of the dependence of lnC (x, t) on x^2 was plotted for steel 3 and HEA from the experimental data after ESA, and a straight line is obtained as a result for both cases. This explains the bulk nature of diffusion, which prevails over grain boundary diffusion. At the same time, the exponent "2" at x indicates that the application of the 2nd Fick's law is justified in the case of ESA due to the fact that the contribution to the total flux from the drift tends to "0".

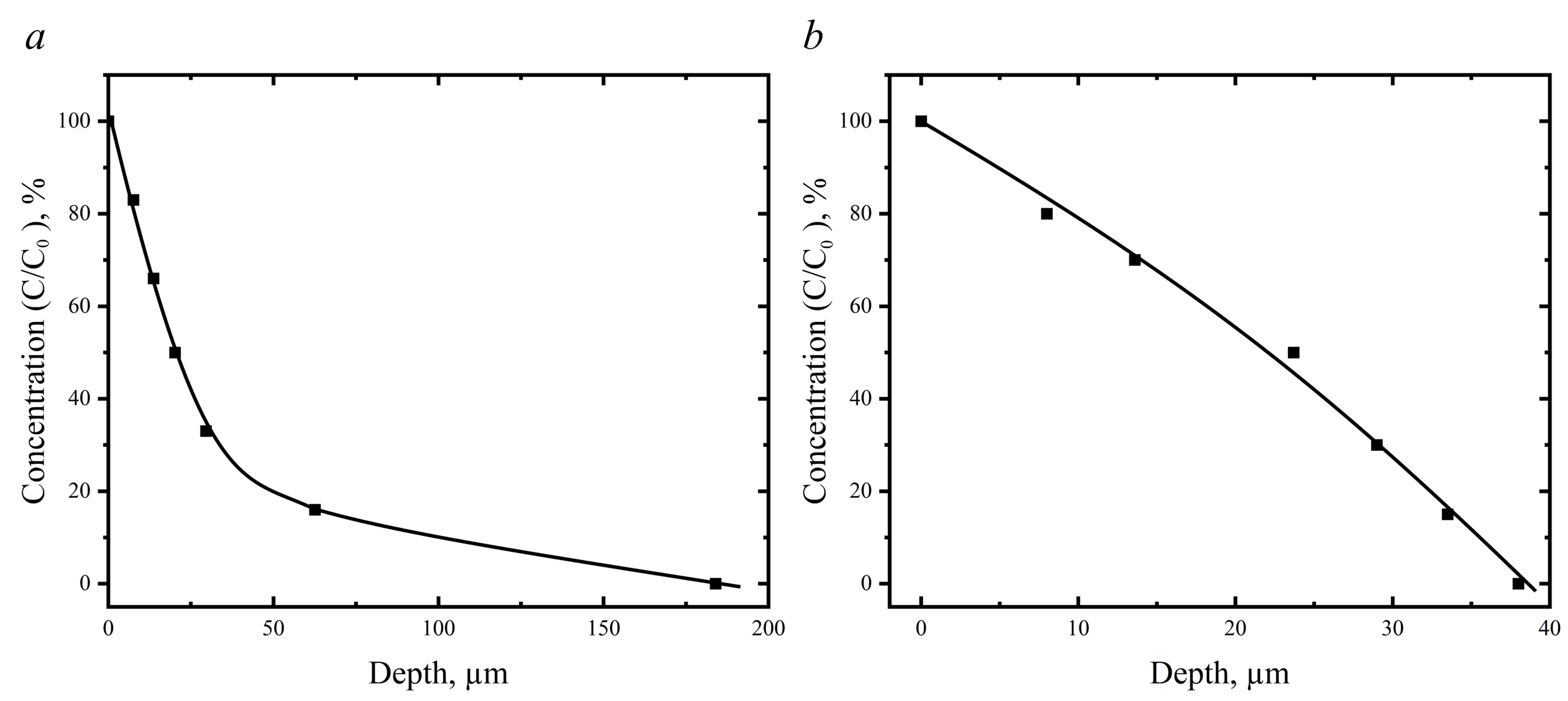
After shock treatment, the values fall on a straight line with power exponents at x: 1.5 and 1 for steel 3 and HEA, respectively. This indicates an anomalous mass transfer and the unsuitability of the application of Fick's 2nd law.

As a result of the directed impact load, the dependence of concentration on depth changed: the concentration maximum of the radioactive tracer shifted to the right, which can be explained by the appearance of an external force, which leads to a symmetry breakdown of the potential barrier for atoms.

The contribution of impact treatment was separated from the mass transfer under the action of complex treatment (ESA+Impact).



Normalized concentration distribution of the isotope in depth in steel 3 (to the left of the maximum) and in HEA (to the right): a) after ESA; b) after complex treatment with ESA+Impact



Result of the shock treatment separation from complex processing

Conclusions

1. For the first time, a technique for determining the parameters of anomalous mass transfer with separation of the diffusion component and drift under the action of the driving force on the basis of experimental data processing is proposed. Based on the numerical value of the exponent n, a conclusion is made about the mass transfer mechanism and the selection of appropriate formulas for finding the mass transfer parameters: D, Def, <V>, F.
2. It is shown that the predominant mechanism of mass transfer under the conditions of ESA and mechanical impact in steel 3 and in HEA is the directional movement of atoms entrained by mobile dislocations since the drift component of the flux equation is significantly larger than the diffusion component by the mechanism of random walks.