



北京大学力学与工程科学学院

Chemo-mechanical coupling in mechanics of solids



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时 间: 10 月 29 日 周三 15:30–17:00

地 点: 北京大学新奥工学大楼 2047

内容简介:

Lithiation of silicon in Li-ion batteries, oxidation of silicon in integrated-circuit and semiconductor technologies, oxidation and fracture processes in polycrystalline silicon microscale parts of MEMS are among important examples of chemical reactions, affected by mechanical stresses, which in turn are generated by transformation strains accompanying the reaction. Such chemical transformations are also accompanied by changing elastic moduli and rheological properties of solid constituents. From the mathematical point of view, such reactions represent coupled problems of chemo-mechanics “diffusion–chemistry–mechanics” with unknown interfaces, the propagation velocity of which depends on the concentration of the diffusing constituent and stresses while the concentration and stresses depend on the interface position. The problem is considered within the framework based on the concept of chemical affinity tensor. Tensorial nature of the chemical affinity for chemical reactions in a solid is discussed. It is shown how the chemical affinity tensor determines the configurational (thermodynamic) force driving the chemical reaction in a solid. Stresses affect the reaction via the affinity tensor. Various models of diffusion near the reaction front are discussed. The cases of elastic and viscoelastic reaction product are studied and principal difference between the cases is emphasised. Examples of boundary-value coupled problems of chemo-mechanics are presented. It is demonstrated how stresses can retard, block and accelerate the reaction. Finally, a volume chemical reaction is considered and its consistency with a tensorial nature of the chemical affinity is demonstrated.

报告人简介:

Alexander Freidin obtained his Diploma in Mechanical Engineering from Leningrad Polytechnic Institute in 1976 at the Chair of Mechanics and Control headed by A.I. Lurie. He got a PhD in Physics and Mechanics at Moscow Institute of Physics and Technology (Phystech) in 1987. In 1993 he joined IPME RAS where, in 1997, he was awarded a Doctoral Degree in Physics and Mechanics. He is a member of the Russian National Committee of Theoretical and Applied Mechanics, member of editorial boards of scientific journals, member of scientific committees of various conferences. He awarded the Title of Beijing Specially Recruited Expert. Currently, he is the head of the Laboratory of Mathematical Methods in Mechanics of Materials at the Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences (IPME RAS), Professor of Peter the Great St. Petersburg Polytechnic University and St. Petersburg University. His research focuses on problems in nonlinear mechanics and thermodynamics of solids, including multidisciplinary problems of chemo-mechanics and stress-induced phase transitions, micromechanics, non-linear elasticity.

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