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The role of defects in the crystal growth and dissolution processes (AFM data)

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We have studied the evolution of dioxydine (2,3-bis(hydroxymethyl)quinoxaline-1,4-dioxide) crystal surface in a solution using the methods of in-situ atomic force microscopy (AFM) and statistical approach. It is the first time when we have received successive images of dioxydine surface dissolution on dislocational spirals of different type. We have studied the differences in sculpture and behavior of multifilar spirals formed by screw dislocations located at distance more and less then six radiuses of the critical nucleus. We show how the form of complex dislocation canal depends on position of canals of single dislocations. It has been established that growth and dissolution on the screw dislocations on the face (100) of dioxydine crystal occurs mainly due to the expansion of elementary steps of growth (8.8 Å).
The statistical data processing reveals considerable differences in tangential dissolution rate on the two spirals, consisting of nine and four screw dislocations correspondingly. Right-screwing growth layers of the left spiral join, at some distance, the left-screwing steps of the right spiral, forming an even more complex source – a growth analogy of dislocational Frank-Read source. The results of calculations show that for the left source steps the average tangential rate is two times greater than that for the right source ones throughout the whole experiment. On the whole, the tangential rate decreases towards the end of the experiment. The rate fluctuations for the steps of both groups also reveal an almost monotonous decrease. This means that the system is working towards equilibrium. This brings forward an important inference: the left and the right part of the same growth source, located at a less than a micrometer distance from each other, have a different effect on the boundary layer of the solution. We have shown that the interface needs to have the horizontal concentration gradient of the substance which would provide a faster tangential rate of the left spiral at growth and a more active decrease at dissolution.
Using atomic force microscopy (AFM) we carried out also ex-situ study of the growth surfaces of natural and synthetic crystals – natural quartz, pyrite, alabandite, topaz, diamond, many crystals of various inorganic water-soluble salts, crystals of organic compounds (aspirin, dioxydine, hydrazine), etc. Comparison of data from in-situ and ex-situ experiments will partially reconstruct the event, which took place in the natural crystals during their growth and to determine what constitutes their surface – «frozen» picture of the growth initiated by defects or dissolution?

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