Solid state wetting and relaxation of nanorelief as patterns of super-fast processes on solid surfaces

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The solid state wetting (SSW) seems to be an interesting phenomenon demonstrating the relativity of differentiation between the solid and liquid states when micro- and nanoparticles are considered as objects of interest. On the one hand, the phenomenon in question can be specially used in a number of technological processes. On the other hand, SSW puts some principal limitations on production and application of nanosized structural units on solid surfaces. These limitations were discussed in our recent papers [1, 2]. In [3] the first accurate experimental study was performed of the spreading of solid Cu microparticles (5-20 μm in size) on the polycrystalline Cu substrate. For the 3 h term the particles in question took a droplet-like form with the equilibrium contact angle approximately equal to 40°. In [1, 2] we put forward a reasonable hypothesis that the SSW phenomenon should be even more pronounced when nanoparticles are put into a contact with the solid surface. And the hypothesis in question was completely confirmed in our MD experiments on Cu (nanoparticle) / Cu (substrate) and Au (nanoparticle) / Au (substrate) systems. No wonder that for nanoparticles the characteristic SSW time t_{ch} was found to be 1-10 ns, i.e. by many orders of magnitude lower than for micronic ones [3]. Using the capillary induced surface diffusion (CISD) concept and some similarity considerations we have also evaluated t_{ch} for Cu nanoparticles using the above value 3h obtained experimentally in [3] for microparticles. And CISD estimations agree well enough with our MD results. Of course, SSW should also take place when the particle and the substrate are presented by different metals that has been confirmed in our MD experiments on solid Pb nanoparticles on the Cu substrate (see Fig. 1). The relaxation (degradation) of the nanoscale relief may be interpreted as another interesting pattern similar, to a greater or lesser extent, to SSW. Using MD we have investigated evolution of nanosized protrusions (including conical ones) and some wells (grooves) on metal and semiconductor (Si) surfaces. The characteristic time t_{ch} of the nanorelief relaxation is usually much smaller than the characteristic time of the SSW of initially spherical nanoparticles.

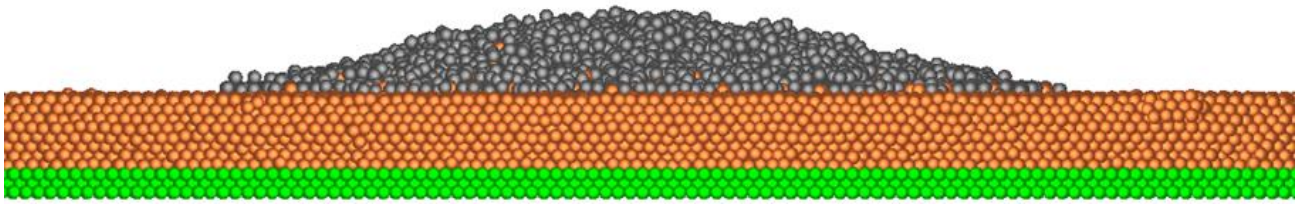

Fig. 1. A Pb solid nanoparticle configuration after spreading on Cu (110) substrate. Grey color corresponds to the particle atoms, orange to non-fixed atoms of the substrate, and the fixed lower substrate layers are depicted by green color.

The work was supported by the Ministry of Education and Science of the Russian Federation in the framework of the State Program in the Field of the Research Activity (project No. 3.5506.2017/BP) and by Russian Foundation for Basic Research (grant No. 16-33-60171, 17-43-690186 and 18-43-690001).

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