GRAPHENE EFFECT ON MECHANICAL RESPONSE OF COPPER FILM

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This research is investigated the effect of the presence of a single layer graphene on the development of the contact plasticity inside a copper underlying substrate. As a matter of fact, a film of copper (deposited on a Si wafer) is the substrate used in the CVD process for graphene production, there is no need for transferring graphene which avoids any possible artifacts. Moreover, the adhesion between CVD-grown graphene and the underlying Cu film is larger than transferred graphene, since during transfer, wrinkles and ripples may form, thus weakening the interaction between graphene and the substrate. The bare Cu-film in the same condition as to produce graphene except that no methane was introduced into the chamber (the last step in graphene production). Nanoindentation was performed on the Cu-film with and without graphene. Nanoindentation was performed on the bare Cu-film also Cu-film with graphene. The same process, as the growth of graphene on Cu-film, was performed on bare Cu just without introducing the methane flow at the last step. The analysis of the force-displacement curves indicates that the presence of graphene modifies the onset of plasticity which appears in the form of a burst which is called pop-in. The first pop-in occurs at lower loads and the pop-in lengths are smaller with graphene in comparison to the bare Cu-film. The magnitude of the effect of the presence of a graphene cap layer varies also with respect to the orientation of the indented Cu grain. In order to understand the root causes of these effects of the presence of graphene on the plastic flow, transmission electron microscopy is used to compare samples after nanoindentation in terms of dislocation structures. 3D discrete dislocation dynamics simulations are performed to analyze the long-range back stress that are generated by the dislocation arrangements with and without graphene. To further extend this research and investigate the known effect of hardening by graphene insertion into metals, another system has been addressed which involves the deposition of a Cu film on top of the graphene layer, lying itself on top of the annealed Cu substrate. The presence of graphene caused marked effect on the indentation response in this case, even larger than in the first configuration.