DISLOCATION GENERATION AND MOTION IN AU(001) AT THE NANOMETRIC SCALE

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Nanoindentation, in conjunction with surface sensitive techniques, such as atomic force microscopies (AFM), are beginning to be used to study the elastic-plastic transition on the nanoscale and examine the dislocation and related defects involved in those first stages of plasticity [1,2]. However, the atomic processes taking place at the initial stages of plasticity in solid surfaces are still full of uncertainties. In particular, more information would be required in relation to the mechanisms involving the nucleation of dislocations, and the possible role played by the surface at the incipient stages of plasticity. Elucidating the role of surfaces is particularly relevant in view of the growing interest in the physical properties of nanostructures.

In previous articles we have used scanning tunnelling microscopy (STM) to image the Au(001) surface after nanoindentation with the microscope tip [3,4]. Local analysis around the nanoindentation point has shown that two special types of dislocation configurations are generated around the latter: 'mesas' and 'screw-loops', both of which intersect the surface and give rise to permanent features that can be disclosed by STM and AFM [5]. In this work, we present new scanning tunnelling microscopy (STM) results about the characterization and motion of these types of dislocation configurations around a nanoindentation. In particular, we report about the spatial distribution of 'mesas' around nanoindentations and their movement as a result of additional nanoindentations in their proximities. We also show and analyse the generation of two types of terraces, resulting from the cross-slip of 'screw-loops' of opposed Burgers vector. We further include theoretical calculations (atomistic simulations and standard dislocation theory calculations) which help to explain the dislocation mechanisms which are responsible for the plastic processes observed in the neighbourhood of the surface. We show that these new data fit very well into a joint description of the mechanical response of surfaces to a nanoindentation and the processes taking place at the atomistic level which results in surface defects.

References

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