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SIZE EFFECT OBSERVED IN SPHERICAL INDENTATION TEST OF SINGLE CRYSTAL COPPER

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The size effect in inelastic behavior of materials is currently studied by many researchers, and the indentation test is a well established tool used to investigate this phenomenon [1]. However, the interpretation of this phenomenon is still discussed [2]. The majority of investigations of the size effect are performed using sharp indenter tips. In the paper we illustrate this effect applying spherical tips of different radii *R*. Spherical indentation enables us to investigate not only the size effect but also the strain hardening effect of the material at different scales. On the other hand, due to lower stress concentration generated in the material than in the case of sharp indenters, more reliable numerical simulations of the test are available. The indentation tests were performed on single crystal copper in micro- and nano-scale, and the topography of residual impressions was measured using scanning profilometer and AFM, respectively. The indentation size effect, for fixed relative penetration depth *h/R* as the tip radius decreases, manifests itself in three forms: the hardness increases, the normalized pile-up height decreases, and the shape of the contact boundary becomes closer to circular one. Using the well-known assumptions that the flow stress is proportional to hardness (Tabor) and the effective strain to *a/R* (Johnson), where *a* is the mean contact radius, the strain hardening effect observed for different tip sizes is discussed. Recently, a new model of gradient-enhanced plasticity of metal single crystals has been proposed [3] and applied to simulate indentation tests. The comparison of numerical and experimental results that follows our earlier paper [4] is presented.

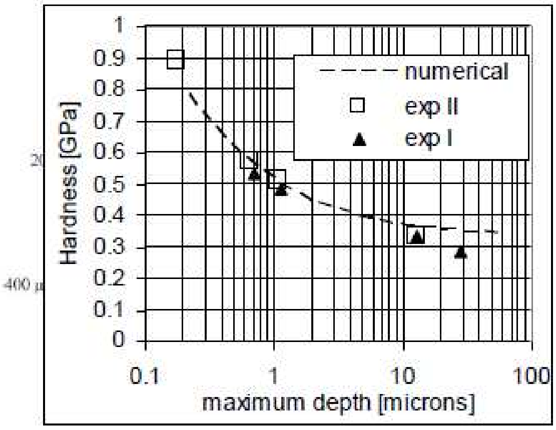

Fig. 1. Dependence of hardness on the maximum penetration depth h at fixed ratio h/R = 0.11;

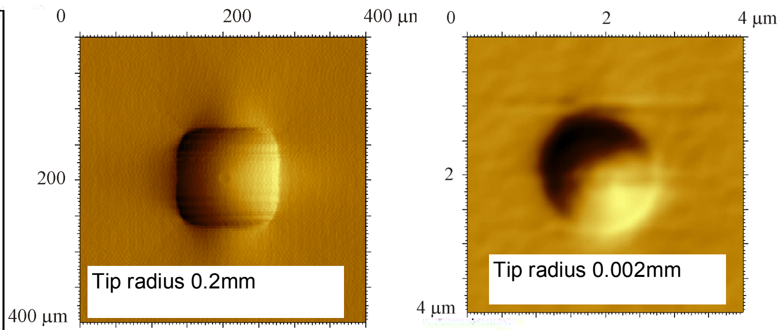

Fig. 2. Different material response in micro- and nano scale. Impressions of spherical tips having different radii for the same depth to radius ratio have clearly a size-dependent shape.

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