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The Effect of Stress and Strain State on the Residual Substructure of Shock-Loaded Nickel

The effect of high-velocity deformation on residual material properties is usually studied under conditions of uniaxial strain (shock loading) or uniaxial stress (Hopkinson bar). A state of uniaxial strain in the specimen requires that there is no material flow normal to the direction wave propagation. In shock loading practice, this condition can be satisfied by choosing lateral specimen dimensions which are large compared to the pulse width of the wave. A truly uniaxial strain state will result in no dimensional change, but any deviation from this state will induce progressive changes in the residual specimen dimensions.

During an investigation of the effect of various shock-wave parameters on residual substructures, such deviations from a true uniaxial state of strain were introduced into the experimental set-up by generating shock waves of very large pulse duration (10μsec) resulting in pulse widths up to one half of the lateral specimen dimensions. The effect of these large pulse durations on the residual substructure of shock-loaded Ni is a large increase in average cell size, see Fig.1. The larger cell size must be a consequence of plastic deformation which occurred under the stresses set up by the passing shock wave, and which reached 20% reduction in plate specimen thickness for the room temperature test.

These results may explain why a drop in residual hardness has been reported in the literature (1) for several materials shock loaded at pulse durations above 2μsec, since yield strength is usually found to be inversely to related to the dislocation cell diameter. The present results also show that the effect of large pulse durations (large mass of driver plate) cannot be interpreted as effect of a possible temperature rise in the specimen during the experiment. Shock loading at 77^{o}K, Fig.1(b) leads to the same large size cell structure as at room temperature, Fig.1 (d). At both small and large pulse durations, however, cells are better defined when the material was shocked at room temperature. This observation in agreement with recent arguments in the literature (2,3) suggests that the original dislocation configuration introduced presumably during the rise time of the pressure pulse can relax into a more stable configuration by thermally assisted dislocation motion.

(1) L.E. Murr and J.Y. Huang, Mat. Sci. Eng. 19 (1975) 115
(2) L.E. Murr and D. Kuhlmann-Wilsdorf, Acta Met., in press
(3) M.A. Meyers, Script. Met. 12 (1978) 21

VI Coloquio Brasileiro de Microscopia Eletronica, 2-7 July 1978,
Sao Paulo, Brasil, p. 134.

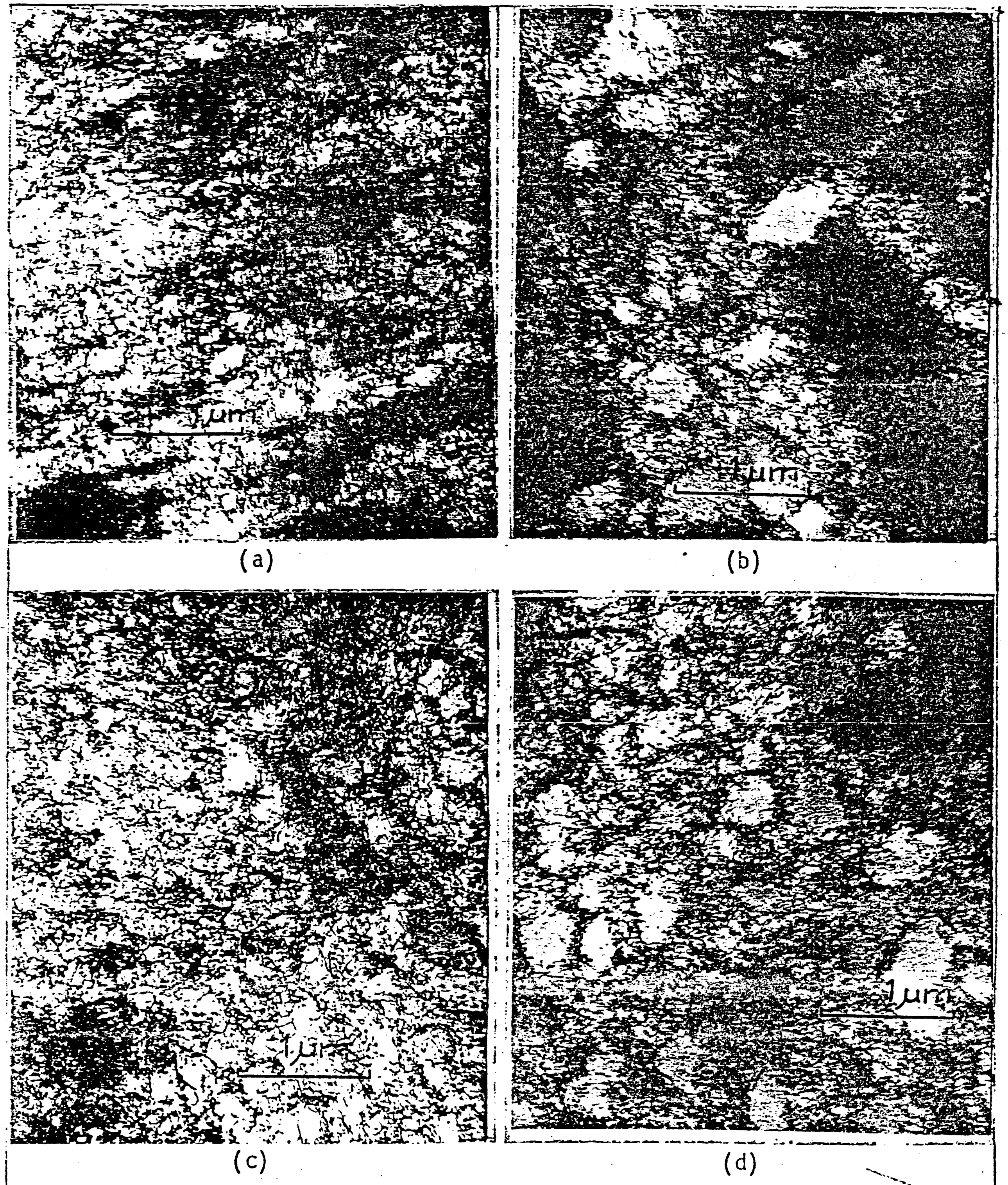

Fig.1 - Dislocation cell structure in Ni shock-loaded at 20 GPa as a function of pulse duration and temperature.

(a) 77°K and 1.2 μsec (b) 77°K and 10 μsec
(c) 25°C and 1.2 μsec (d) 25°C and 10 μsec