The presented work aims at deepening the understanding of the initiation of fatigue cracks in metals. The work is based on an argument of Mura and Nakasone [1] where an energy criterion is used to predict the initiation of a fatigue crack from a slip band. The discussion is based on the evolution of dislocation networks, as these are the prime cause for permanent deformation in metals. Using high performance computing, 3D dislocation dynamics simulations [2] are performed over several cycles to study the growth of the dislocation arrangement. Then the evolution of energy in the system is determined, including all relevant terms such as: energy of the elastic field of the dislocations and their interaction, core energies, dissipation, energy stored in the continuum and external work. A hypothetical crack is placed in the region of the largest dislocation density and it is checked, if the energies stored in part of the dislocation network should be exchanged with the surface energy of a crack to lower the overall energy state of the system. The size of the crack is based on the number of dislocations that were previously formed in the network, as the motion of these dislocations towards the hypothetically formed free surface would form the actual crack. The presented work requires only minimal input in form of elastic constants and dislocation mobilities (for example from molecular dynamics). Results are presented for different materials (Cu and Mg), grain sizes and loading rates.