Atomistic theory of the shear band direction in amorphous solids

Ashwin Joy
Department of Chemical Physics, Weizmann Institute of Science, Rehovot, Israel

Email: ashwin.joy@weizmann.ac.il

Abstract:

It is well known experimentally that well-quenched amorphous solids exhibit a plastic instability in the form of a catastrophic shear localization at a well-defined value of the external strain. The instability may develop to a shear band that in some cases is followed by a fracture. It is also known that the values of the yield strain (and yield stress), as well as the direction of the shear band with respect to the principal stress axis, vary considerably with variations in the external loading conditions. In this talk we will present a microscopic theory of these phenomena for two-dimensional a thermal amorphous solids that are strained quasistatically. We will present analytic formulas for the yield strains for different loading conditions, as well as for the angles of the shear bands. We will explain that the external loading conditions determine the eigenvalues of the quadrupolar Eshelby inclusions which model the nonaffine displacement field. These inclusions model elementary plastic events and determine both the yield strain and the direction of the shear band. We will show that the angles of the shear bands with respect to the principal stress axis are limited theoretically between 30◦ and 60◦. Available experimental data conform to this prediction.