PROPAGATING INSTABILITIES IN PERIODIC MEDIA

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Under tension low carbon steels exhibit inhomogeneous deformation. This phenomenon driven by dislocations is called Lüders banding. This instability creates fronts of localized strain that propagate in the structure. To date, only simple geometries, sheets and tubes, have been studied while the development of architectured materials have been accelerated thanks to additive manufacturing. A subclass of those materials are so-called lattice structures which can be defined as a tessellation of unit-cells periodically distributed. This emerging class of advanced materials provides new kinds of possibilities in terms of mechanical properties. The behavior of lattice structures is two-fold according to their mode of deformation, bending-dominated or stretched-dominated. Bending-dominated structures exhibit low stiffness while stretched-dominated structures have higher stiffness.
This work deals with such materials with predetermined morphology in order to develop lightweight metallic structures with capability to localize deformation thanks to their geometry. We investigate the effect of the architecture on the global behavior of the entire structure. Especially, how bands can interact with a lattice and how to control initiation and propagation of localized strain with the architecture. Figure 1 represents the example of the diamond lattice solicited in several directions in the plane. An elastoplastic material model is used in this work to simulate the Piobert-Lüders band formation and propagation. The model also considers large deformation framework for plasticity with periodic boundary conditions in order to represent the architectured material.
Nucleation and propagation of material instabilities depend on the geometry and the relative orientation of the solicitation. Propagative and non-propagative behaviors are identified for the Piobert-Lüders bands and related to the type of geometries. Material instabilites affect the mechanical behavior of the structure as far as they are governed by the architecture. Consequently, controlled local instabilities can lead to specific macroscopic behavior.

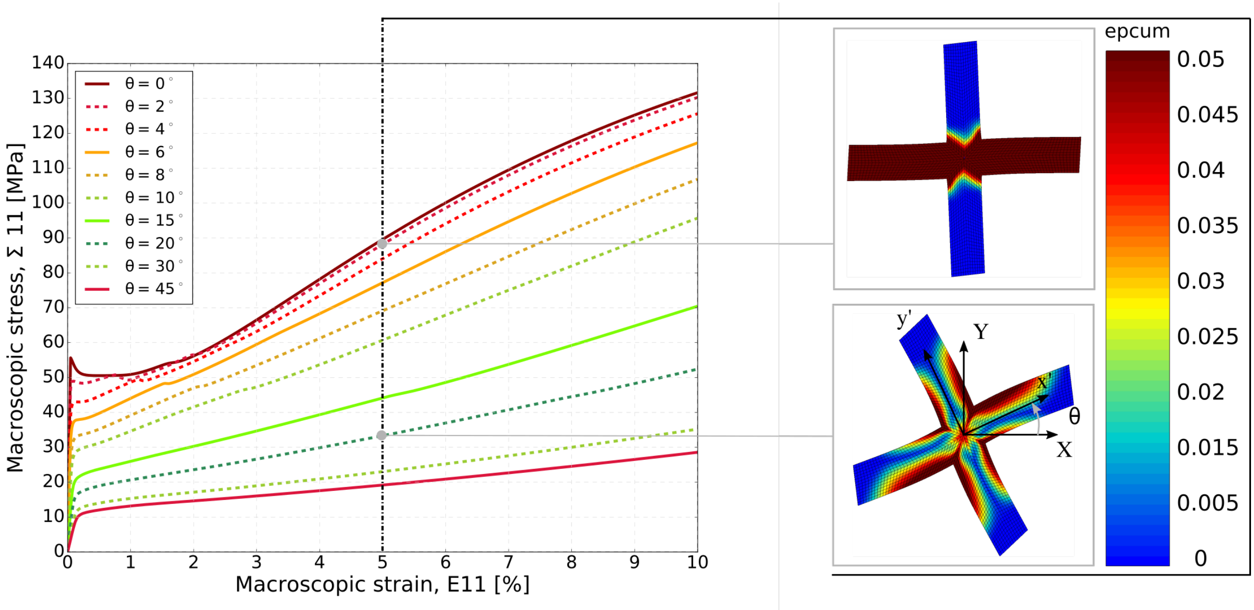

FIGURE 1 – Macroscopic behavior of the diamond lattice solicited (dir. X) in in-plane directions with Piobert-Lüders material instabilities and map of the cumulated plastic strain for 2- and 20-oriented cell for a macroscopic strain at 5% .

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