Geophysical Research Abstracts
Vol. 14, EGU2012-10337-1, 2012
EGU General Assembly 2012

Understanding fast macroscale fracture from microcrack *post mortem* patterns

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Dynamic crack propagation drives catastrophic solid failures. In many amorphous brittle materials, sufficiently fast crack growth involves small-scale, high-frequency microcracking damage localized near the crack tip [1]. The ultra-fast dynamics of microcrack nucleation, growth and coalescence is inaccessible experimentally and fast crack propagation was therefore studied only as a macroscale average. We will see how to overcome this limitation in polymethylmethacrylate, the archetype of brittle amorphous materials: We reconstructed the complete spatio-temporal microcracking dynamics, with micrometer / nanosecond resolution, through post mortem analysis of the fracture surfaces [2]. We found that all individual microcracks propagate at the same low, load-independent, velocity. Collectively, the main effect of microcracks is not to slow down fracture by increasing the energy required for crack propagation, as commonly believed, but on the contrary to boost the macroscale velocity through an acceleration factor selected on geometric grounds. Our results emphasize the key role of damage-related internal variables in the selection of macroscale fracture dynamics.

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[2] C. Guerra, J. Scheibert, D. Bonamy, D. Dalmas, *Proc. Natl. Acad. Sci. USA* **109**, 390 (2012)