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Scratch test as a fracture process: from soft to hard materials
ANGE-THERESE AKONO, Dept of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA, PEDRO MIGUEL REIS, Dept of Civil and Environmental Engineering & Dept of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA, NICHOLAS XAVIER RANDALL, CSM Instruments, Needham, MA, USA, FRANZ-JOSEF ULM, Dept of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA — The scratch test consists of driving a probe, at a certain depth, through a material and is most likely the oldest technique for the mechanical characterization of materials. Although it is widely used in strength testing, the presence of residual chips during the process suggests that a fracture mechanism is at play. We investigate the link between the material fracture properties, the probe geometry and the resulting forces using a combination of precision experiments and Linear Elastic Fracture Mechanics analysis. An analytical model is developed that is applicable both at the macro and micro scale, and that can take into account different probe geometries. Rationalizing the mechanics involved allows us to introduce a novel experimental technique to accurately determine the fracture toughness from scratch tests. Application of this technique to mechanical testing on metals, polymers and ceramics yields values for the fracture toughness that are in excellent agreement with conventional methods such as the three-point bending test, albeit in a way that is less destructive and more scalable. As such, our method to determine materials fracture properties represents an important new development in the field of mechanical micro-characterization.

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