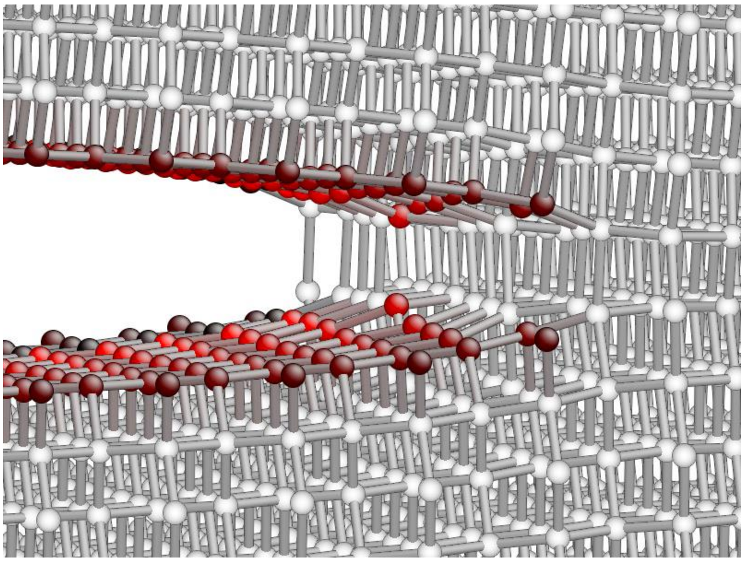
When fast cracks run slow - breaking brittle crystals slowly

Everyday experience suggests that when brittle materials like glass or silicon wafers break they crack very fast, usually at a large fraction of the speed of sound in the material. In an article published in *Physical Review Letters* this week HEmS researchers James Kermode, Gábor Csányi and Alessandro De Vita present QM-based atomistic simulations together with new experimental results from collaborators at the Technion in Israel that overturns this intuition, by showing how cracks in silicon can propagate very slowly (~100 m/s). This goes against the conventional scientific wisdom that chemically unaided crack propagation is impossible in pure silicon below ~2000 m/s because of a phenomenon known as the 'velocity gap' where cracks jump almost instantaneously from rest to very high speeds.

The team used quantum mechanical calculations to predict that slow fracturing of silicon is possible at any chosen crack propagation speed under suitable temperature and load conditions. The modelling work was combined with new experiments demonstrating fracture propagation on the Si(110) cleavage plane in the 100 m/s speed range, consistent with the team's predictions. The research explains how this low speed fracture is made possible by new 3D crack propagation modes that combine the formation and migration of "kinks" along the crack front.

These results suggest that many other brittle crystals could be broken arbitrarily slowly in controlled experiments, and are potentially useful for designing materials with improved mechanical properties.



Slow crack propagation proceeds in three dimensions on the (110) cleavage plane in silicon through the formation and advance of kink pairs.

JR Kermode, A Gleizer, G Kovel, L Pastewka, G Csányi, D Sherman and A De Vita,
Low Speed Crack Propagation via Kink Formation and Advance on the Silicon (110) Cleavage Plane, *Phys. Rev. Lett.* **115,** 135501 (2015).

http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.115.135501