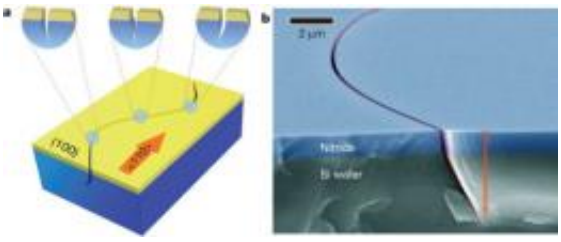
Group uses controlled cracking for nanofabrication

May 10 2012, by Bob Yirka



Formation mechanism of an oscillating crack. Image (c) *Nature*
doi:10.1038/nature11002

(Phys.org) -- When creating nanomaterials, cracking is generally considered a problem; it usually means something has gone wrong and the result, as with other material making processes such as glass or ceramics, almost always means either reprocessing or sending the sample to the trash bin. Now however, a research team in South Korea has found a way to cause cracking on purpose when fabricating a nanomaterial, to produce a required result. They describe their process and results in their paper published in the journal *Nature*.

To come up with their method, the team modified an old-fashioned technique commonly used for fashioning stone. Instead of smashing or chiseling, small holes are made in the stone where pieces of wood are inserted. Soaking the wood causes it to expand and crack the stone in just the right way.

In the lab, the researchers first etched very small notches and steps into a silicon substrate. They followed that by covering the substrate first with a very thin layer of silicon dioxide and then with one of silicon nitride, creating a sandwich. Without the notches and steps, cracks would develop spontaneously and chaotically in such a sandwich; with them however, the cracking can be controlled. The notches cause stress in the substrate to be concentrated, forcing the cracking to begin where they were made. The steps serve as strong borders, confining the crack to just the area where it is wanted. In this way, cracks that occur are not allowed to follow the crystalline structure as they normally would, and are instead directed along desired pathways. Using this technique the team created cracks that formed straight lines, some that were oscillatory and some that were stitch-like. They say it could also be used to make cracks that actually form around corners. Also they point out how the same technique could be used to create channels in nanomaterials that rely on moving very tiny amounts of liquid material.

Using this technique, the team suggests, would generally be cheaper for nanofabrication than traditional electron beam etching and less time-consuming. They believe it could be used for making semiconductors and silicon chips as well as for making microfluidic products.

More information: Patterning by controlled cracking, *Nature* 485, 221–224 (10 May 2012) doi:10.1038/nature11002

Abstract
Crack formation drives material failure and is often regarded as a process to be avoided. However, closer examination of cracking phenomena has revealed exquisitely intricate patterns such as spirals4, oscillating and branched fracture paths and fractal geometries. Here we demonstrate the controlled initiation, propagation and termination of a variety of channelled crack patterns in a film/substrate system comprising a silicon nitride thin film deposited on a silicon substrate

using low-pressure chemical vapour deposition. Micro-notches etched into the silicon substrate concentrated stress for crack initiation, which occurred spontaneously during deposition of the silicon nitride layer. We reproducibly created three distinct crack morphologies—straight, oscillatory and orderly bifurcated (stitchlike)—through careful selection of processing conditions and parameters. We induced direction changes by changing the system parameters, and we terminated propagation at pre-formed multi-step crack stops. We believe that our patterning technique presents new opportunities in nanofabrication and offers a starting point for atomic-scale pattern formation, which would be difficult even with current state-of-the-art nanofabrication methodologies.