# The Department of Civil and Environmental Engineering at the University of Houston presents...

## CIVE 6111 Graduate Seminar

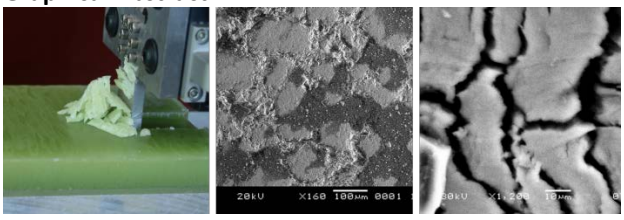
## Understanding Fracture at the Nanoscale: From Butter to $CO_2$ Geological Sequestration

**Ange-Therese Akono**
Assistant Professor and Louis Berger Junior professor
Department of Civil and Environmental Engineering
Northwestern University

**Friday, April 6, 2018**
2:45PM-3:45PM
Classroom Business Building (CBB Room) 106

**Abstract**
The mission of my research laboratory is to elucidate fracture resistance at multiple length-scales, with an emphasis on novel fracture assessment methods at the nanometer and micrometer scale. Fracture is a pervasive phenomenon which can lead to devastating consequences such as high-cost maintenance efforts to repair fractured structural components, loss of structural integrity in oil and gas wellbore operations, limited mobility in athletes and children after a bone fracture, and reduced life expectancy for the elderly after a hip fracture. Despite significant progress over the last decades, there is still a strong need for advanced methods to shed light on the physics of fracture at small scales while accounting for extrinsic factors such as loading conditions, temperature and relative humidity, along with intrinsic factors such as microstructure, mineralogy, and chemistry. I will present a novel method devised in my research group: scratch test for fracture testing. Although the principle is simple and age-old—push across the surface of a softer material with a hard probe— the mechanics of scratch testing are complex and not fully understood. I will present the underlying theoretical model while drawing from linear elastic fracture mechanics, computational fracture modeling, and nonlinear fracture mechanics. Using the method of complex potentials, the *J*-integral, finite element simulations, and the energetic size effect law, new solutions have been formulated in my research laboratory to investigate the ductile-to-brittle transition in macroscopic and microscopic scratch tests. I will then illustrate the potential of fracture-oriented scratch testing to address major challenges of the next century such as human welfare, energy independence, $CO_2$ geological sequestration, and advanced multifunctional materials. From the failure micro-mechanisms in cortical bone, to toughening behaviors in organic-rich shale, and fluid-rock geochemical reactions in host rock, the hybrid theoretico-experimental framework is able to bring new insights, thereby creating new venues of research.

**Graphical Abstract**



**Bio**
Dr. Ange-Therese Akono is an Assistant Professor and Louis Berger Junior professor in the Department of Civil and Environmental Engineering at Northwestern University. Dr. Akono holds a PhD (2013) and an MSc (2011) from the Massachusetts Institute of Technology (United States), along with an MSc (2009) from the École Polytechnique (France). Dr. Akono's honors include the NCSA faculty fellowship (2016-2017), the ASCE New Faces of Civil Engineering Professionals Award (UIUC, 2016), the ASCE nomination for the DiscoverE New Faces of Engineering Award (UIUC, 2016), the Academy for Excellence in Engineering Education Collins Fellowship (UIUC, 2015), and the MIT Energy Initiative Fellowship (MIT, 2009). Dr. Akono's laboratory investigates fracture and failure mechanisms in complex materials systems from the molecular level up to the macroscopic scale. This research is articulated over three main thrusts: environment-friendly and high-performance structural materials, natural and nano-engineered biomaterials, and geological materials such as organic-rich shale or reservoir host rock. Dr. Akono's areas of expertise include nano-mechanics, fracture analysis, nanotechnology, advanced experimental testing, and multiscale modeling.