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Origami and kirigami on the nanometer-scale

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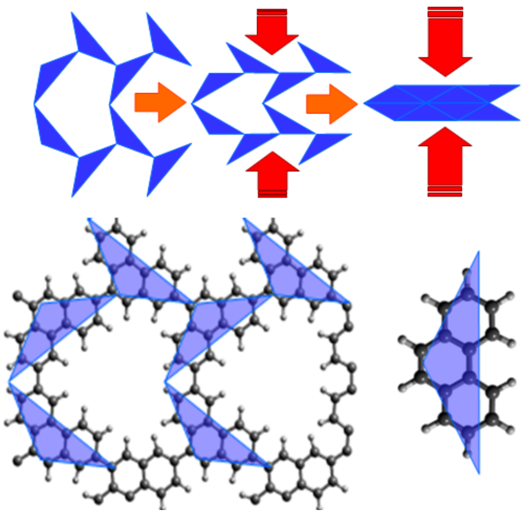

Figure 1
Top: global deformation in a kirigami lattice of linked triangles.
Bottom: porous graphene as nanometer-sized counterpart of a kirigami lattice of polymerized phenanthrene molecules. (Ref. [5]).

Two-dimensional (2D) systems such as graphene have an unusual flexibility to change their shape [1]. Since shape and function are closely related, physical properties including the electronic structure can be tuned by structure modifications. Similar to macro-scale *origami,* 2D monolayers of graphene can fold on the nanometer scale to hollow fullerenes and nanotubes [2], even to nano-tori [3]. Relative stability of the different structures can be determined to a surprising accuracy using approaches common in Engineering including the continuum elasticity theory. The continuum approach also provides a superior description of soft acoustic phonon modes in 2D structures [4]. Similar to macro-scale *kirigami*, 2D nanostructures can be cut on the nanometer scale as seen in Figure 1. Similar to macro-scale structures, they may display unusual deformation characteristics including a negative Poisson ratio indicating that a structure pulled in one direction may become wider in the other direction [5]. Ability to fine tune the pore size in such nano-kirigami structures may be useful for water desalination. Finally, layers of graphene and other 2D substances can be stacked like cards to modify the electronic structure near the Fermi level including the fundamental band gap. The electronic structure of bilayer graphene has been shown to depend sensitively on relative twist [6] and shear [7], providing new insight into electron correlation and superconductivity in 2D systems.

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References:

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