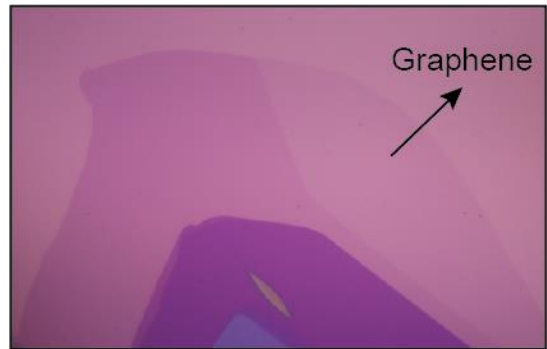


# Layering Down to the 2D Limit

By Kyle Hwangbo

In 2004, two physicists, Andre Geim and Konstantin Novoselov, took the scientific community by the storm when they published an article demonstrating the first isolation and identification of graphene – a single sheet of Carbon atoms. This marked the birth of a new field called two-dimensional (2D) materials, and for this remarkable accomplishment, they were awarded the 2010 Nobel prize in physics. Perhaps the most striking aspect of their discovery was the simplicity in which they accomplished such a momentous task. They found that by simply placing a bulk graphite onto scotch tape and then folding and peeling the tape several times, which thins the graphite each time, eventually leads to graphene (**Figure 1**).



Since then, scientists have discovered that a myriad of other materials can be similarly exfoliated down to the atomically thin limit. In addition to having huge potential in technological applications, many of these 2D materials have interesting properties that are absent in their 3D bulk counterparts and act as model platforms to study fundamental ideas in physics. It also turns out that individual layers of these materials can be vertically stacked on top of each other – like assembling a tower with Lego blocks – to create a van der Waals (vdW) heterostructure, which exhibits novel composite properties (**Figure 2**). With all the colorful choices of atomic Lego blocks, there are a limitless number of heterostructures that can be assembled. These heterostructures can also be fabricated into traditional nanoscale electronic devices, like a transistor, and have many proposed applications related to solar energy harvesting, energy storage and energy systems. In particular, researchers aspire to create new compact types of photovoltaics, batteries, LEDs, and memory devices using these 2D heterostructures.

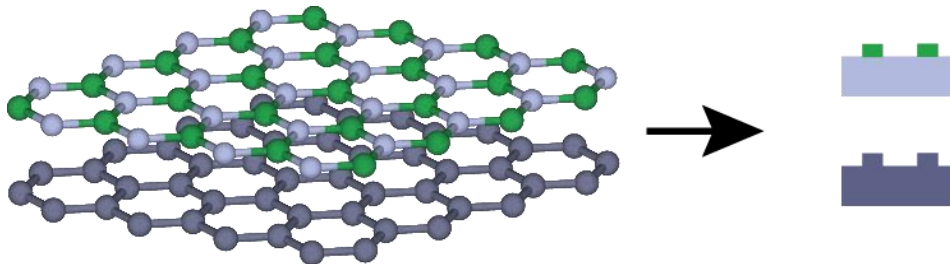
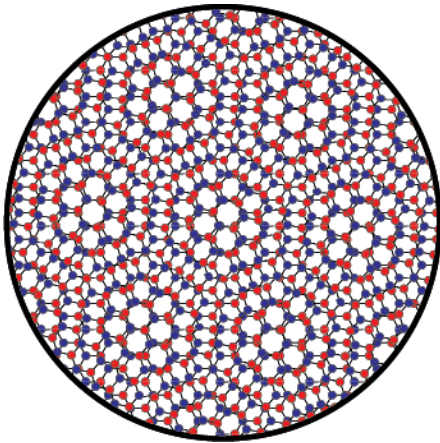


Figure 2: Example of how two monolayers can be stacked on top of each other like Lego blocks.

As a nascent scientific field, there are frequent paradigm shifting and exciting innovations. Recently, scientists have also found that the overall properties of the heterostructures can depend very sensitively to the twist angles between the layers. When two atomic layers of the heterostructure form a moiré pattern (**Figure 3**), the nanodevice can host very interesting emergent

phenomena, such as superconductivity and topologically insulating states, which have important implications in quantum computing. Many current quantum computing research is focused on implementation of quantum computers in superconducting electronic circuits and in topological insulators; these 2D materials offer another promising platform for future quantum computers. With deeper understanding of 2D materials' properties and some innovation opening up access to mass production, we may see a future where our everyday electronic devices and technology around us become as thin and as light as they can be: *atomically*.



*Figure 3: Cartoon illustration of a moiré pattern created by rotating two sheets of atoms with respect to each other.*

**Kyle Hwangbo is currently conducting research as a CEI Graduate Fellow. Learn more about Kyle's research and STEM path at our upcoming virtual Lunch & Learn on December 14 at 11:45 am.**