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Cooking with atoms!

Research on two-dimensional materials growth

Two dimensional materials are the thinnest materials on Earth, they are formed by a single layer of atoms organised in a plane. Imagine a sheet of paper, but 1.4 million times thinner! These layers have very interesting properties such as being really good conductors of heat or electricity. Because of that, a lot of research is focusing on implementing them in our daily life. But before this happens we need a fast and efficient way to manufacture them, and this is what we call "growth techniques."

The first 2D material to be manufactured was graphene, a single layer of carbon atoms organised in a honeycomb lattice. Like Graphene, other 2D materials exist. A very promising one because of its insulating properties is hexagonal boron nitride, a layer of boron and nitrogen atoms. So, what makes these materials so interesting? With graphene or boron nitride we can build tiny electronic components, such as transistors or LEDs. Their size will allow us to have electronics that are so small that they could be imbedded in everywhere. Imagine having sensors in your clothes or a whole computer imbedded the window of your house, and you wouldn't even see them!

The first graphene layer was obtained with a surprisingly simple method; by peeling off a single layer of graphite with scotch tape. Since then, other 2D materials have also been manufactured this way. Nevertheless, the sizes of the "peeled" layers can not be controlled, which makes device-manufacturing very complicated. Another approach is to "grow" the 2D layer. This type of manufacturing method allows us to control the size and the quality of the materials, but how does it work?

Growing 2D materials is just like cooking

Your ingredients are what we call the "precursor molecules," the gas that contain the atoms that we need for the 2D layer. And the frying pan is what we call the "catalytic substrate." Imagine that we are trying to cook a bunch of frozen peas. The peas are the atoms that we need for the 2D layer and they are organised in frozen chunks, a.k.a. the molecules. The first growth step is to deposit the precursor molecules on the substrate or, in other words, to put the frozen peas in the pan. The catalytic substrate will then dissociate the molecules into radicals. We can understand that step as turning on the heat on our frying pan and getting rid of all the ice. Now we have the interesting atoms (the peas) free to move around in our substrate (the pan). Atoms will tend to form the structure that requires them the least amount of energy to maintain, and this is a crystal structure. So if we keep giving them energy in the form of heat, they will start moving around and forming crystals that will eventually cover our whole substrate.

The problem with growing 2D materials comes when we don't have a catalytic substrate to break the precursor molecules. How can we defrost the peas without a hot pan? With our research project we propose a method to overcome that need. We designed a very simple setup that breaks the molecules already in the gas phase. With a shower of accelerated electrons we break the molecules and the pieces deposit on the substrate, ready to form the 2D layer. In this way, when the peas come to the pan, they are already unfrozen, and they just need a bit of heat to organise in the crystal layer. With our method we are able to grow 2D materials in virtually any substrate, which brings us a step closer to direct fabrication of 2D materials-based electronics.

So let's cook!

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