

The end of the Silicon Era

The modern world is on the verge of entering a new era, an era known as, “beyond the Moore’s law”. This law, that has governed the entire computer industry for more than 50 years, predicts that the number of transistors in an integrated circuit will be doubled every two years. By the current rate, the transistors, which are at the very border between nanometres and atomic dimensions, will exceed the physically available sizes of the three-dimensional transistors within the next decade. As a result, fundamentally different sets of materials have to be investigated, will they be the end of the Silicon Era?

In 2010 the Nobel Prize in Physics was awarded to A. Geim and K. Novoselov for the discovery of a new material called “graphene”, a single layer of carbon atoms. By using a simple Scotch Tape, Geim and Noveselov were able to peel off these single atomic layers from a chunk of graphite. This newly found two-dimensional material had very interesting properties, such as an extreme electrical conductivity, which was way beyond any known three-dimensional structure. However, because of its high conductivity, it made it difficult to use by itself within the transistor industry dominated by semiconducting materials, such as silicon. Another intriguing member of the ever-growing family of the two-dimensional materials is an insulator called hexagonal boron nitride. As hexagonal boron nitride shares the same structure as graphene, it becomes interesting to examine if these two atomic layers can be stacked on top of each other, to form so-called two-dimensional heterostructures, with new possibilities and a reduced size way beyond any three-dimensional structure. Furthermore, by a combination of an insulating and a conducting layer, the highly desired semiconducting properties could be achieved, hence creating a structure with a possibility to become the new future of transistors and nanoelectronics.

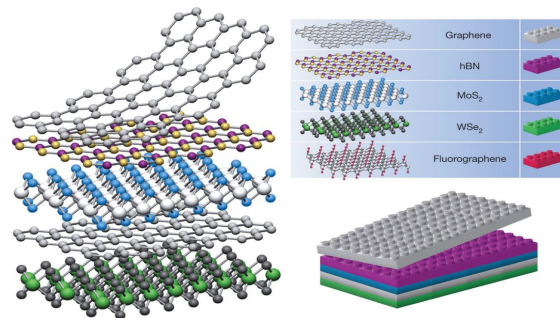


Figure. Family of two-dimensional materials. On top, graphene and hexagonal boron nitride. Further, visualizing the 2D heterostructures as stacking lego bricks. Reproduced from: <http://dx.doi.org/10.1038/nature12385>

In my project, I studied how the two-dimensional heterostructure between graphene and hexagonal boron nitride can be formed and characterized it using techniques with resolution on the atomic scale. In addition to contributing to the understanding of stacked two-dimensional materials in general, my study opens new research directions as it surprisingly showed that it is possible to bury and store charge in the hexagonal boron nitride.

Handledare: **Jan Knudsen**
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Fysiskainstitutionen, Avdelning för synkrotronljusfysik
Lunds universitet