JOHANNES JOBST Leiden Institute of Physics

Viewing 'nothing' leads to revolutionary electronics

Physicist Johannes Jobst is a modern-day magician. His work conjures up images of hidden – and empty – electronic states from thin air. By cataloguing these states, he gains spectacular new insights into the fundamental properties of materials such as graphene. How looking at 'nothing' is paving the way for a new nanomaterials revolution.

By George van Hal

JOHANNES JOBST (Nuremberg, 1984) did his PhD on the electronic transport in graphene in Erlangen, Germany. He is currently working at Leiden University as a postdoctoral VENI fellow.

Solar cells, novel sensors and the computer chips of the future: these are only some of the things physicists and engineers might be able to design, using a new technique developed by physicist Johannes Jobst and his colleagues at Leiden University. Using a new type of low-energy electron microscopy he developed, Jobst is able to explore and control the cornucopia of Van der Waals materials, combinations of atom-thin materials such as graphene.

Van der Waals materials are created by combining layers of materials only a few atoms thick. Sticking these layers together - almost like Lego bricks - creates interesting electronic properties. 'These are encoded in their band structure,' says Jobst.

This structure describes the movement of electrons in the materials. 'We are probing very high-energy bands,' Jobst explains – so high that electrons occupying them move through free space, only loosely bound by their parent atoms. Usually these high-energy bands are unoccupied – nothing more than thin air. Jobst is able to reveal their presence by shooting at them with an electron beam. 'If they have the right amount of energy, these electrons are absorbed,' he says, thus unravelling the hidden band structure.

This is important when combining several layers to form a new Van der Waals material. Sometimes these layers start behaving like an entirely new material, while at other times they stay perfectly insulated, remaining clearly distinct.

Whichever happens, the evidence shows up in their band structure.

Using this, Jobst showed that layers of boron nitride stay distinct from layers of graphene. 'Boron nitride completely isolates graphene', says Jobst. This comes in handy because graphene is very sensitive to its environment. A single collision with a molecule already changes its conductivity. Encapsulating graphene in boron nitride solves that problem. Jobst: 'This is very interesting for the electronics of the future.'