Transferring Low Dimensional Materials

Contents

1. Nanowires

Due to the limited amount of TEM image windows, design of the Nano-Chip and the size of semiconducting/metal nanowires, it is becoming more and more demanding to deposit nanowires deterministically on our chips. Here we describe a process to transfer semiconducting nanowires, which is actually generic for all nanowire transferring to our Nano-Chips.

What are you dealing with?

A nanowire is a nanostructure, with the diameter of the order of a nanometer (10−9 meters). Generally, the dimeter of nanowires is smaller than 200 nm, with a length ranging from 1-10 nm; more accurately saying, that are the dimensions we are dealing with. Smaller structures are not suitable to be transferred with this method we are describing right now.

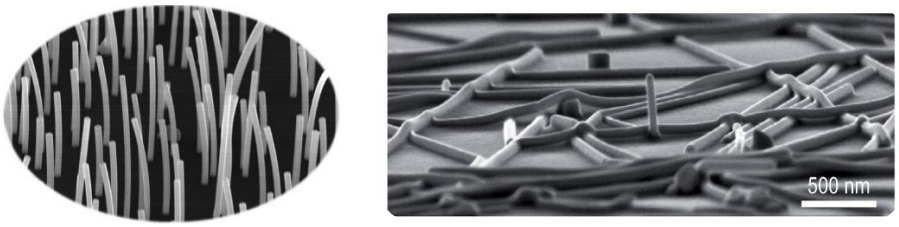


Figure 1: Examples of semiconducting nanowires and metallic nanowires

Setup

You need a **microscope**, preferably a long working distant one to gain a larger space to work. In order to manipulate nanowires, a **manipulator** with precision control is required. Depends on the properties of the nanowires and your concerns, one can either use Tungsten tips, glass tips (hard, more damages) or Indium tips (soft, less damage). For Tungsten tips, one could easily buy from the market. For Indium tips, you always have to create by yourself, this then requires a **heater** to melt down Indium [A detailed paper on nanowire transferring setup]. *Worth to notice, Indium is toxic to human body.* Below is a picture of such setup in TU Delft.

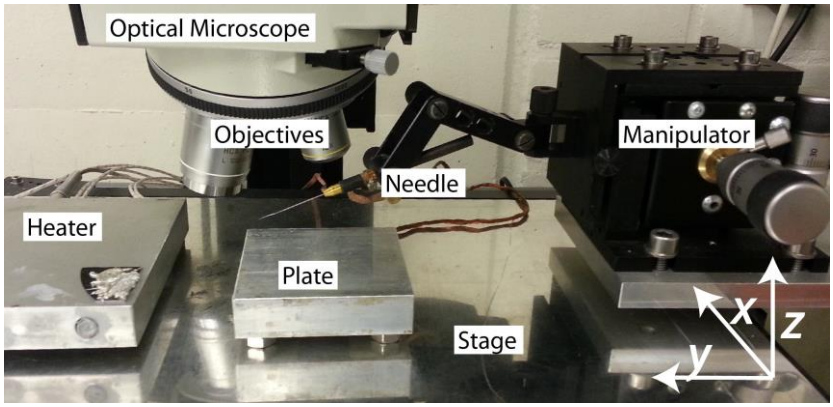


Figure 2: A nanowire transferring setup from TU Delft

How does it work?

1. Prepare your nanowire growth mother chip, put it on the plate which is underneath the microscope.

2. Either you are using Tungsten/Glass tips which is already sharp enough, or you melt down Indium and put your normal needles in and retract slowly to form a sharp Indium tip. It is essential to have a sharp tip in order to quickly pick up and transfer nanowires, therefore it might take quite a while before you can start transferring nanowires with Indium tips.

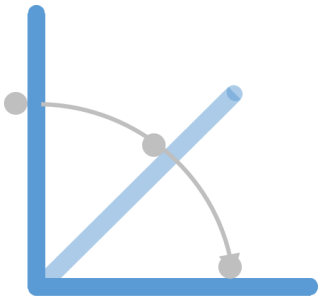


Figure 3: Typical trajectory to pick up a nanowire. Grey spot indicates the needle and the nanowires are represented here as blue lines. In reality, nanowires will bend during picking up process.

3. Move the tip close to nanowire growth chip, going down slowly while changing focus of your microscope, until both tips and nanowires are in focus. Now one is free to pick up nanowires by push nanowires with the tip to break them down from the stamps. Due to van de Waals force, nanowires will stick to the tips. Then move the tips to the Nano-Chips.

4. Same as in step 3, bring the tip, which now has nanowire on it, in focus again, slowly move closer to Nano-Chip. Once it is at the location where one wants to drop nanowires, just wipe over the tip on it. As soon as nanowires touch the surface of the Nano-Chip, due to the larger contact area, the van de Waals force is also stronger, nanowires then will leave the tip and land on the Nano-Chip.

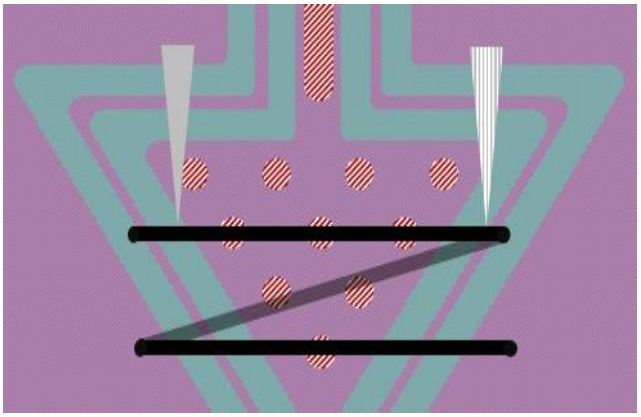


Figure 4: Moving of nanowires on our Nano-Chip substrate. The nanowire (blackline) which does not land on the right spots could be push with the tip (grey triangle) to the right location.

5. If the nanowires are not precisely located, you could always push it a bit with your tip. The freedom here is however quite limited.
6. Repeat this process until you transferred enough nanowires on your sample.

What are the tricky points?

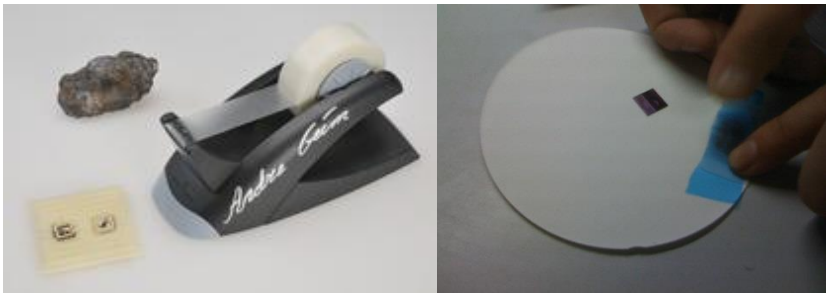
1. A long working distance microscope.
2. Good tips. However, since nowadays there are commercial Tungsten tips available, the real bottleneck is the practice.

2. Graphene

Graphene transfer is not a difficult task after so many years of development. Traditional method of graphene transfer is to simply using scotch tape to exfoliate graphene from a graphite and then stick to targeted substrate. Here we show a more advanced method to transfer graphene layer deterministically.

Setup

You need a small piece of graphite, a scotch tape to peel graphene off from the graphite.

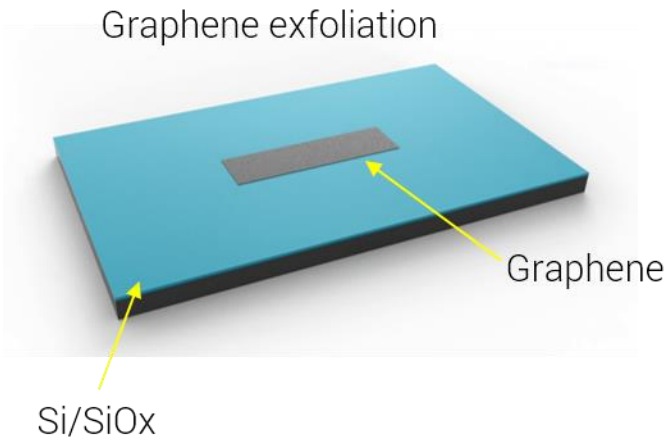


A substrate to temporarily put graphene on before transferring to DENS Nano-Chips. Here we assume the substrate is a SiOx/Si wafer.

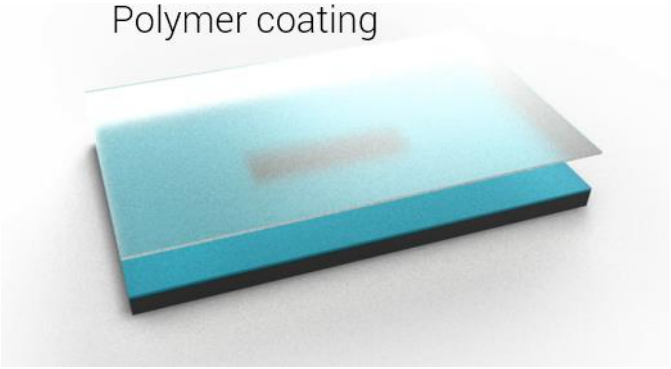
The same as for nanowire transferring, one needs an accurate micromanipulator to position graphene in a bicker filled with water. One also has to either pump out or evaporate all water to bring graphene in contact with Nano-Chip, therefore either a heater or a small pump is needed. Lastly to remove polymers used for transferring, some relevant solvents are required.

How does it work?

1. Start with exfoliated graphene in a SiOx substrate.

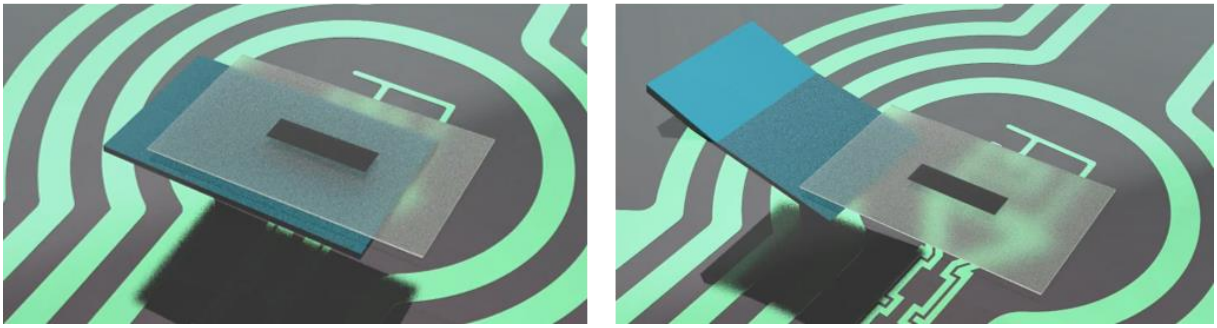


2. After graphene is transferred to the substrate, spin coat the whole substrate with a layer of hydrophobic polymers.

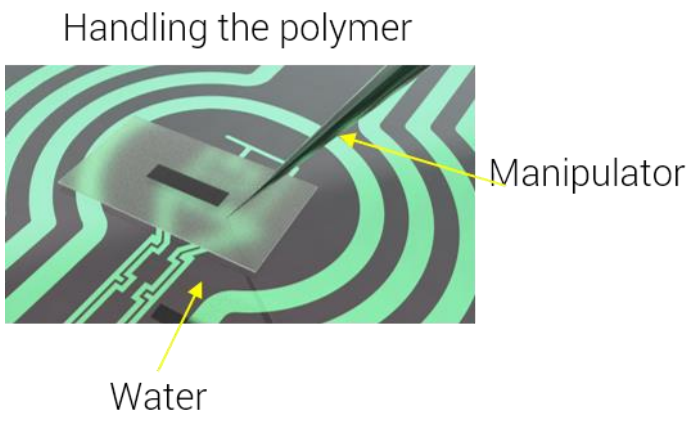


3. Then dip the polymer coated substrate in water. Due to the hydrophobic force, graphene will be peeled off from the substrate together with the polymer layer.

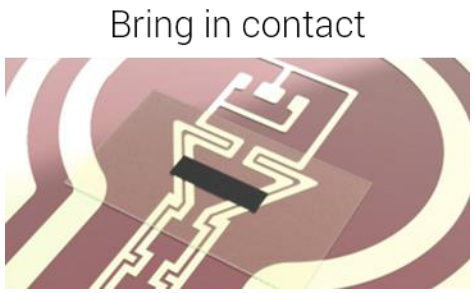
Peeling in water



4. In the same bicker where graphene and the polymer is peeled off, use the micromanipulator to carefully move graphene to our Nano-Chip



5. Align graphene with Nano-Chip as good as possible, and then drain the water to bring graphene and Nano-Chip in contact.



6. Remove polymer with relevant solvents.