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Evaluation of Atomic Layer Etching Possibility at Lund Nano Lab

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Popular Science Description

Nowadays electronic devices are getting smaller and much more efficient. However, it's getting much harder to fabricate such small devices. Specifically, device fabrication with feature sizes below 10 nm (a human hair is 100,00 nm wide) is a big challenge. For this, atomic level control is needed. Atomic layer etching (ALE) is one of the key technologies that can provide atomic controlled etching of different materials by a cyclic etching, where an (sub) atomically thick layer is etched in every cycle. There are also other technologies, which have a potential for the sub 10 nm fabrication. For instance nanoimprint lithography, which is alike book printing but for extremely small features in nanometer range, and epitaxial semiconductor nanowires grown from seed catalytic particles by different epitaxial techniques have a very big potential for extremely fine fabrication of nanostructures. These techniques are also very active research areas in Lund and have already enabled many important applications. This is why the combination of ALE with these techniques may open up many new interesting opportunities. For example, the nanoimprint lithography can be only as good as the stamps, which are used for the nanoimprint, and ALE may provide a very good mean of the stamp fabrication with subatomic precision. Different III-V semiconductor nanowires are very important for their electrical and optical properties. Diameter of the usual nanowires lies in the 40-100 nm range and with ALE it might be potentially possible to shrink the nanowire diameter to the sub 10 nm range. In this research work we used a system for reactive ion etching, similar to the systems, which are widely used in semiconductor industry for semiconductor device fabrication, for testing ALE possibility in Lund Nano Lab. We demonstrated that with this equipment it is possible to perform ALE and used this process for etching semiconductor horizontal nanowires and to make stamps for nanoimprint lithography. Surprisingly, we found that, due to some specific properties of the ALE process and a hexagonal cross section of nanowires, which we used in our experiments, after ALE each nanowire is split in to two very thin nanowires. We believe that here the inclined nanowire surfaces act as a mask for the etch process and that potentially this technique can enable fabrication of ever smaller semiconductor devices in a controllable and industrially relevant way. For instance, a core part of every transistor is a transistor channel and we can foresee that this technique may enable splitting of the transistor channel into two channels without additional expensive and challenging lithographic steps. In this way we may enable further downscaling of transistors in a very economical and practical way by this helping further downscaling of electronic devices.