High throughput fabrication of Single Electron Devices based on Silicon Nanowires with embedded Quantum Dot

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Abstract

We are developing a high throughput fabrication process of single-electron devices (SED). The SED is base in on silicon nanowire (SiNW) in which a quantum dot (QD) will be generated.

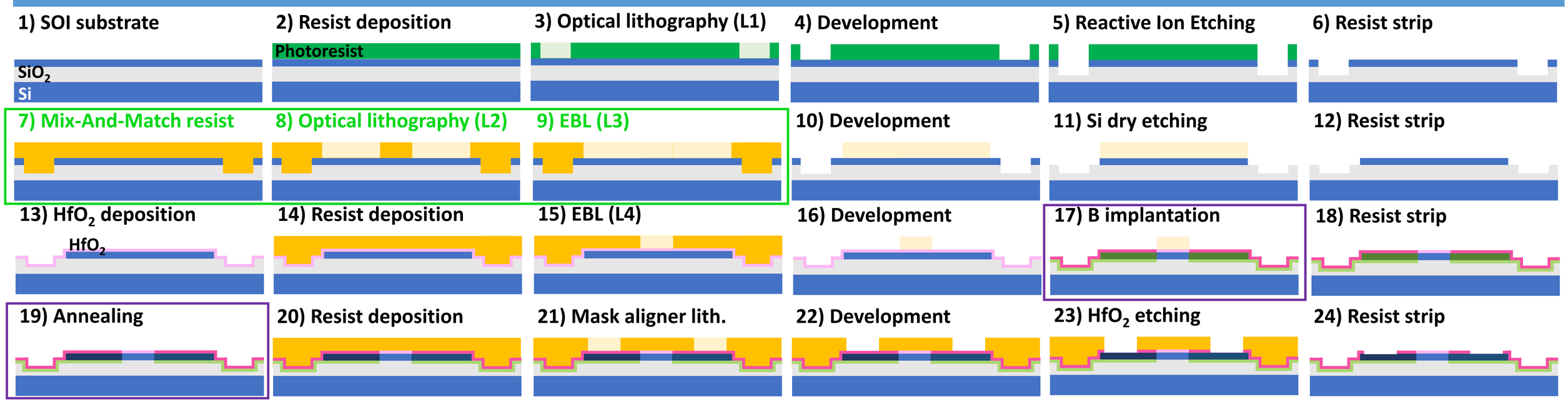
The main features are:
- High accuracy and dimensional control
- Mix-and-match approach based on optical an electron beam lithography (EBL) with 5 lithographic levels.
- Placement of a QD in a SiNW by means of ion implantation.

Keywords: ***SED, Quantum Dot, Nanowire, Mix-And-Match approach***

Objectives

- Produce a reliable SiNW platform to experiment novel nanofabrication process of SED.
- Fabrication at wafer scale.
- Placement of the QD in the middle of the SiNW.
- Ultimately achieve deterministic single doping.

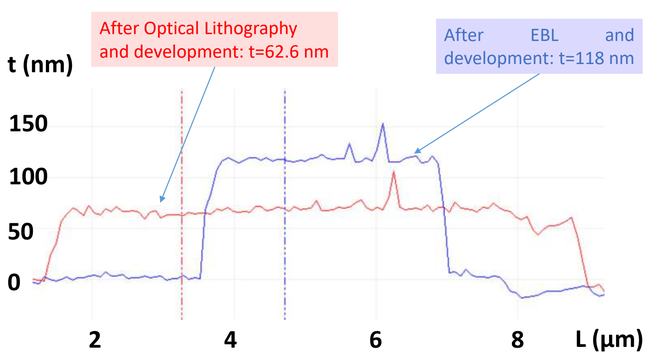
Fabrication process

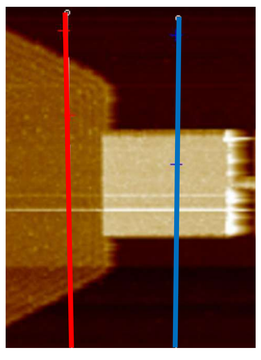


Results

Mix-And-Match

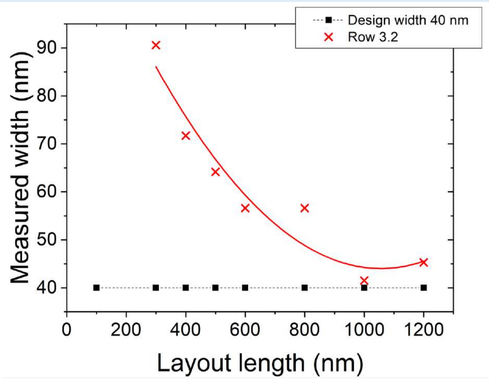
Height of the resist after lithography



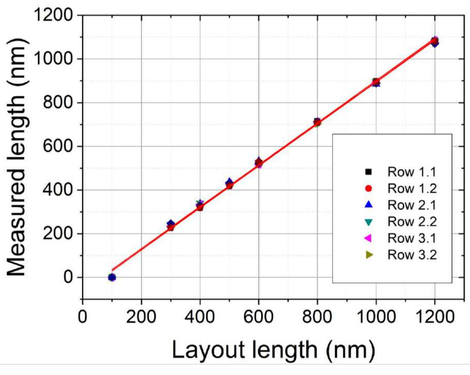


Dimensional characterization

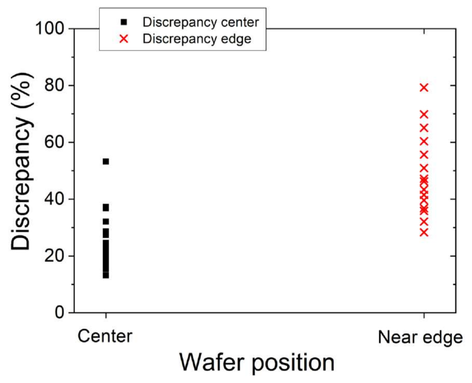
Proximity effect due to the EBL exposure



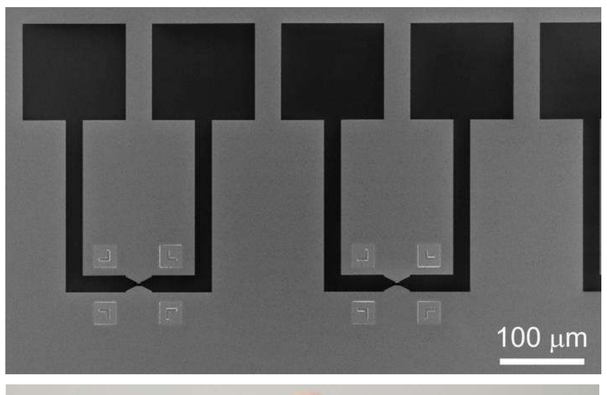
Length of the SiNWs

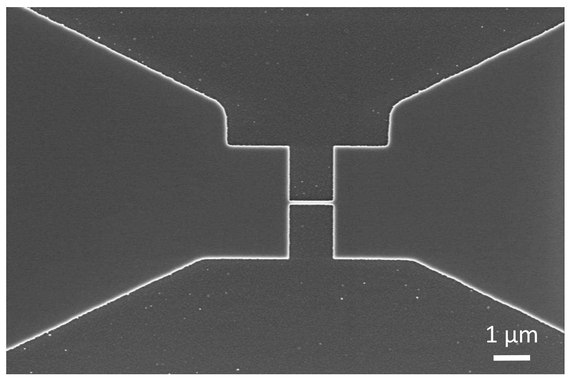


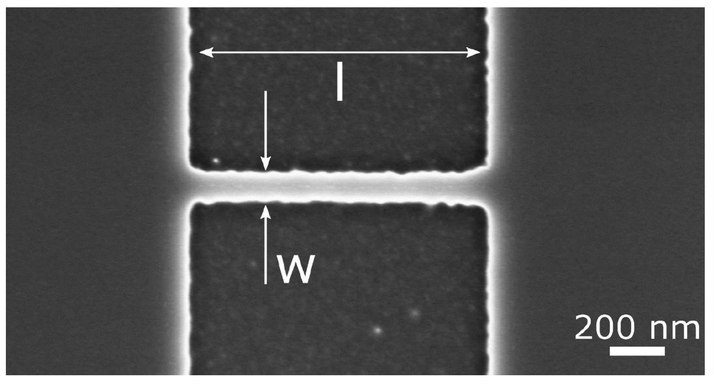
Uniformity analysis

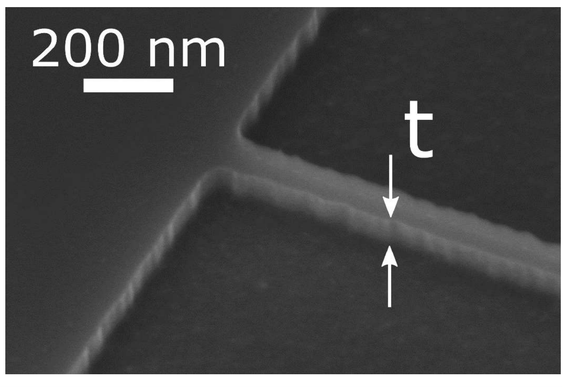


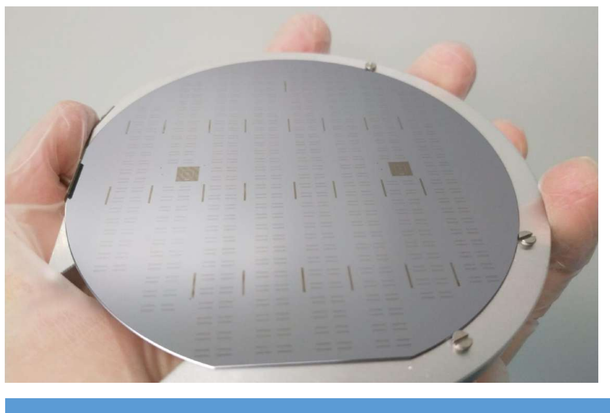
SEM characterization











Conclusions

- Mix-and-match resist has been tuned properly.
- The alignment marks allow an appropriate alignment among the lithographic levels.
- The correlation between the layout width and the real one of the SiNWs improves as the length increases (Proximity effect is reduced).
- High throughput fabrication at wafer level has been demonstrated, getting more than 5000 individually connected SiNWs, with higher dimensional accuracy at the center of the wafer compared with the edge.

Future work

- Continuing the process at full wafer.
- Tuning the process to reach higher agreement between the layout dimensions and the real dimensions of the nanowires.
- To improve the smoothness of nanowires.
- Continue the development of a method to place a QD in the middle of the SNW in a deterministic manner.

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