Size Effects on Dopant Activation in Si Fins

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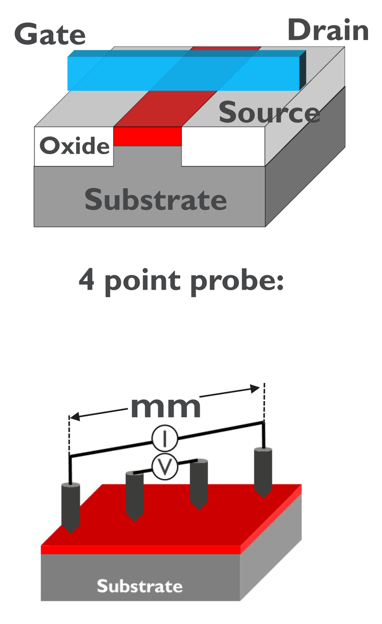
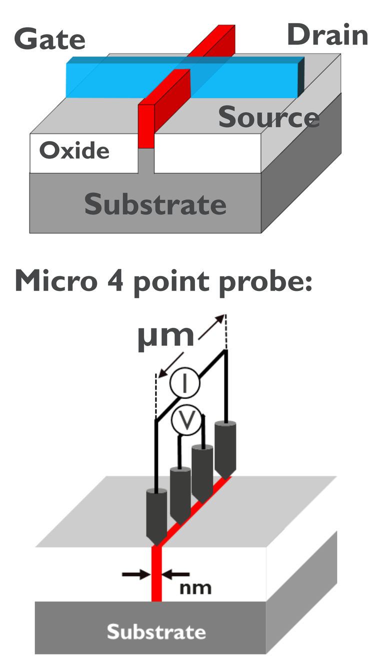
1. Introduction

2D technology (MOSFET):



3D technology (finFET):



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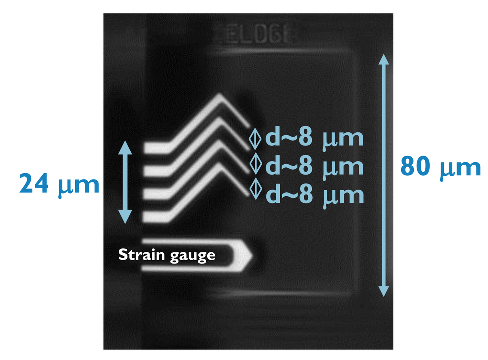
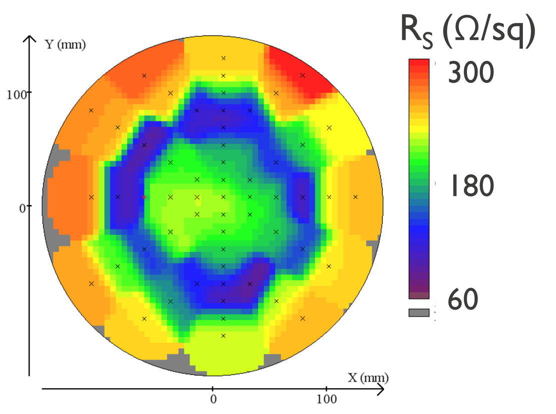
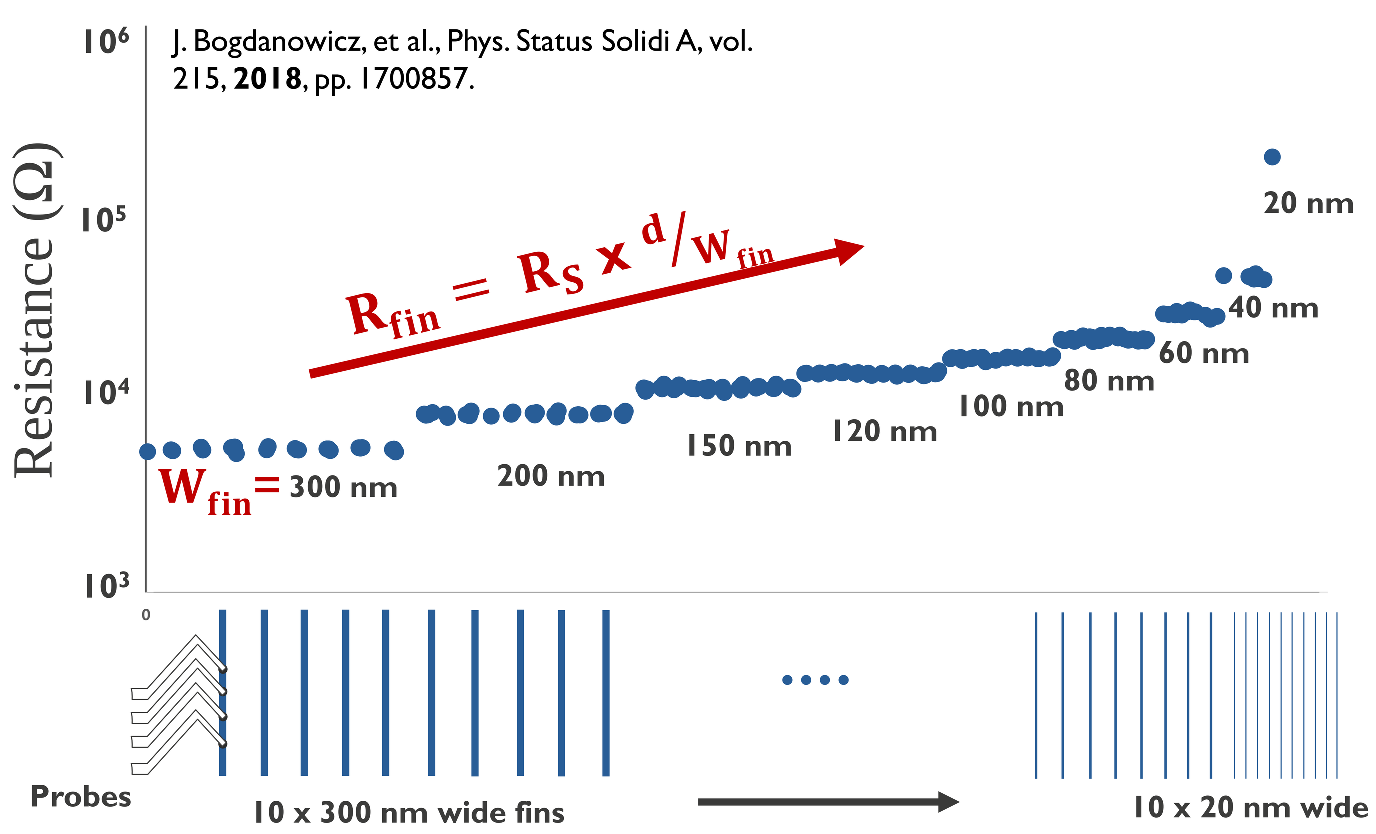
2. Micro-four point probe: from pads to fins

- **Pads:** Technique is commonly used for measurements on **blanket** and on **large pads** (> 20x35 µm²).



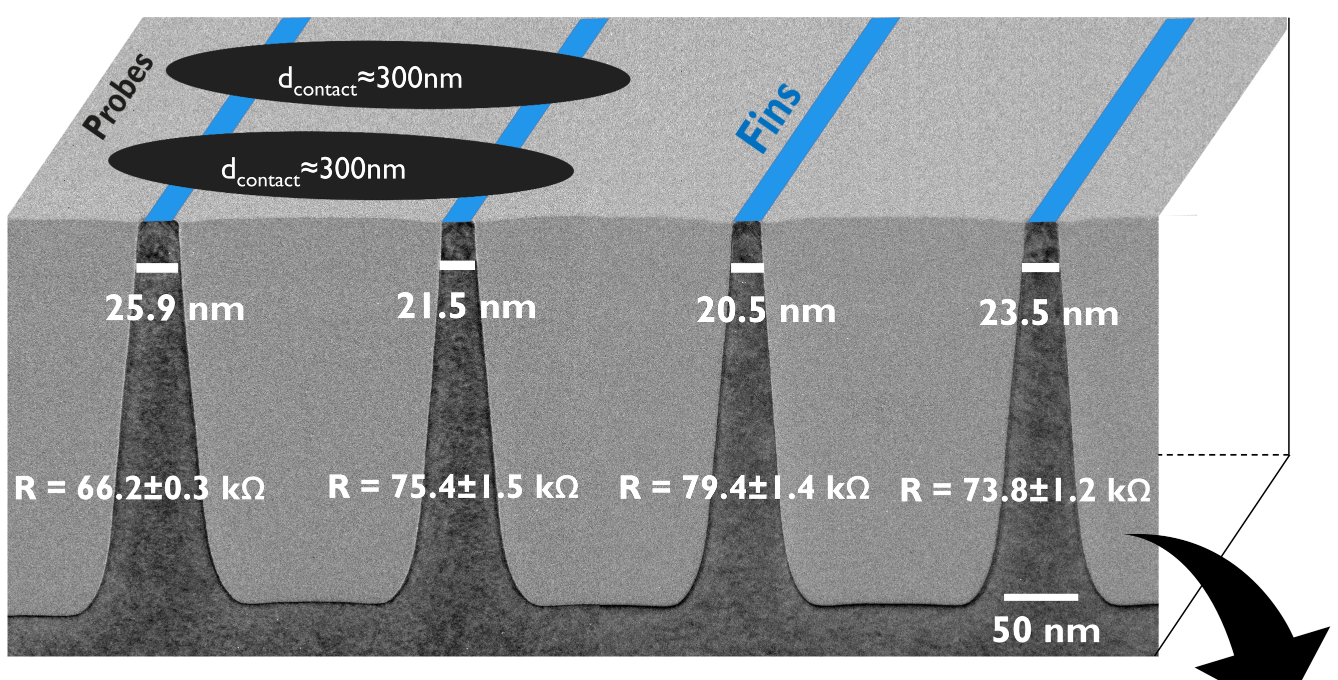


- **Fins:** Can be aligned to fins and measure **fin resistance**.

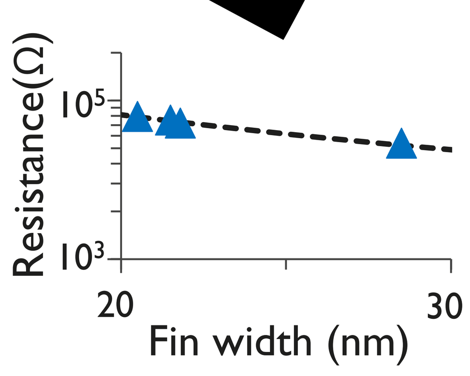


3. Measuring on dense fins

Additional challenge when fin pitch < electrode contact size:



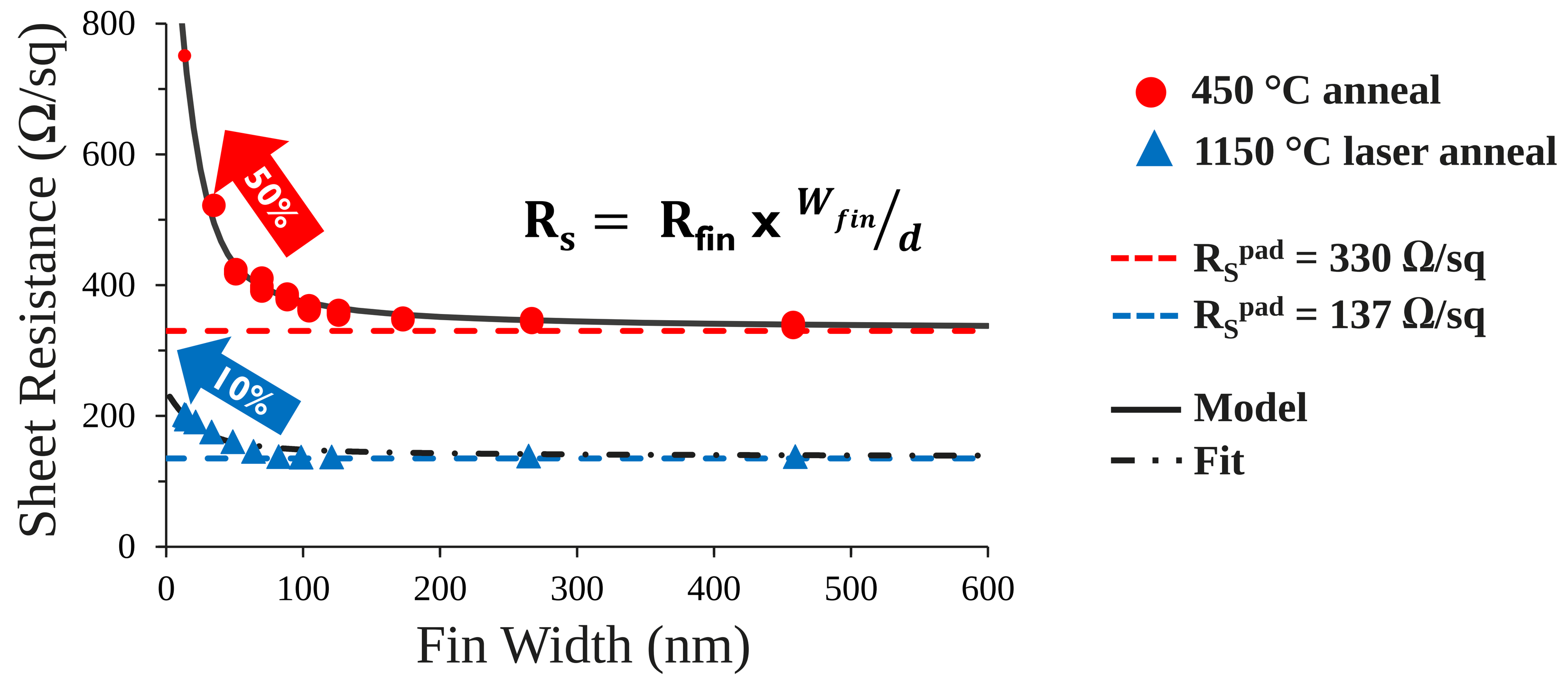
- **Electrical contact** between the µ4PP electrodes and the fins is controlled such that only a single fin is contacted.
- **Measured resistance** follows resistance estimated by model (see next box).



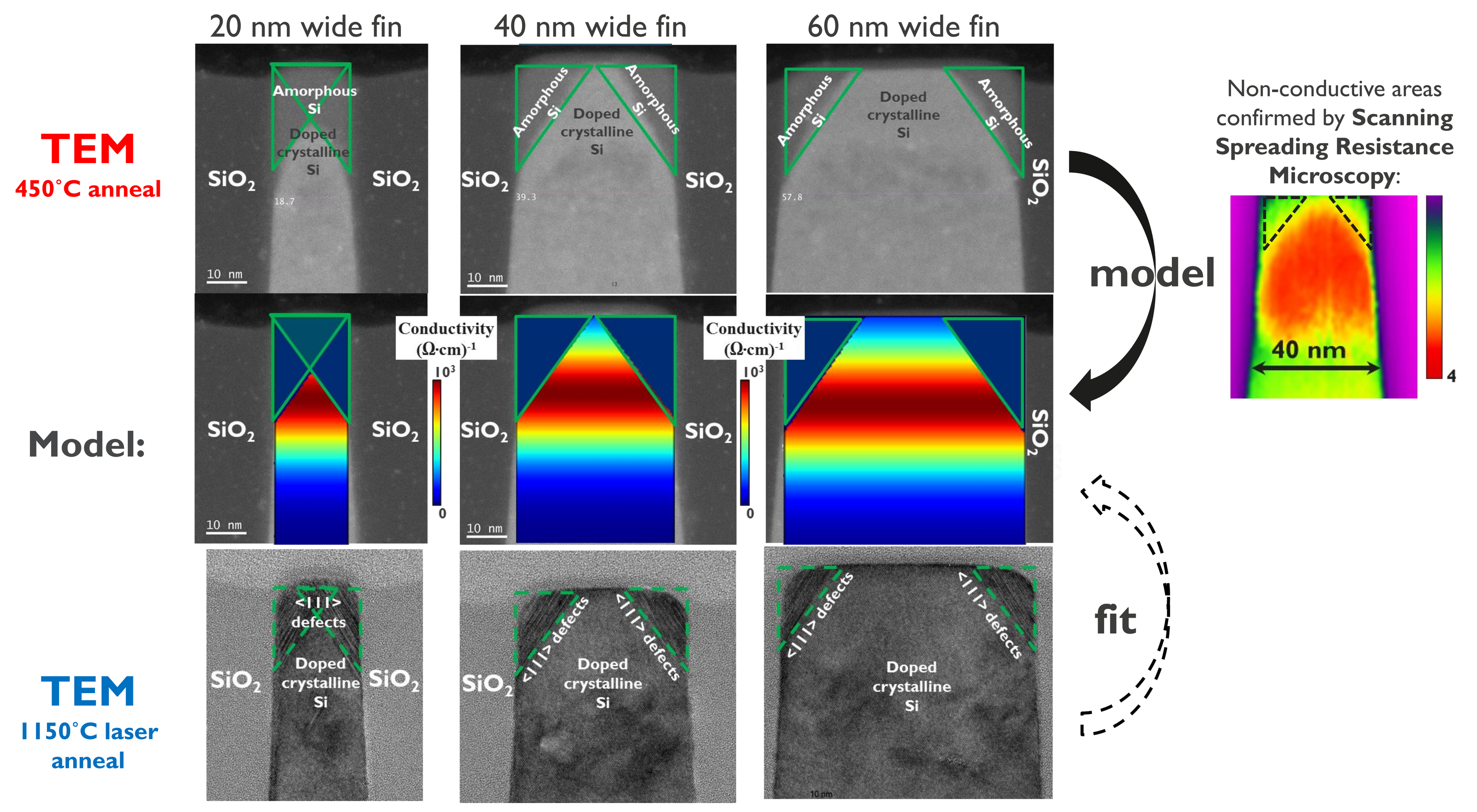
S. Folkersma, et al., Beilstein Jour. of Nanotech., vol. 9, **2018**, pp. 1853-1857.

4. Size Dependent Dopant Activation

- **Fin width dependent** sheet resistance (R_S) of B implanted Si fins as measured by µ4pp.
- R_S of widest fins comparable to R_S of a large pad of the same material.



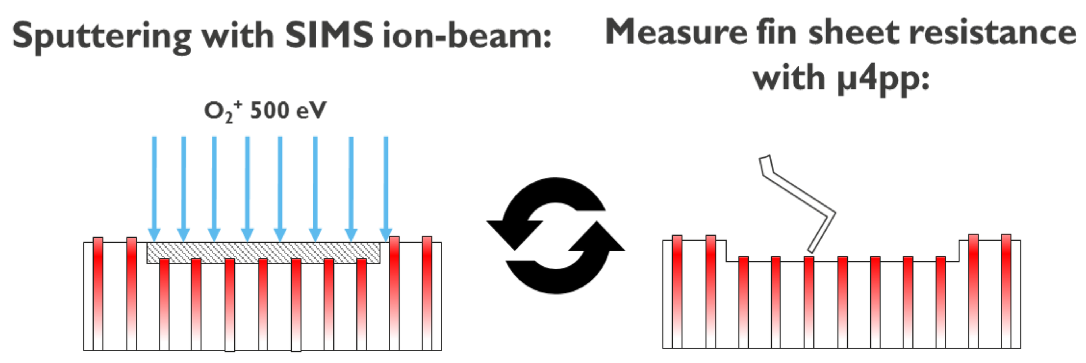
- Model explains increase in R_S due to **non-conductive amorphous silicon** present after **450°C anneal.**



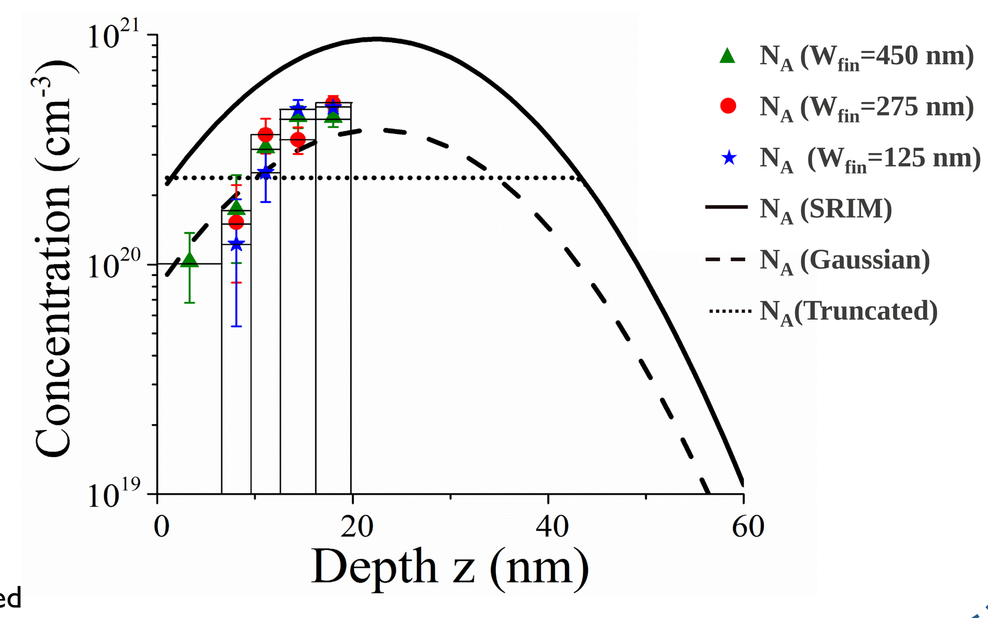
- Defective area present after **1150°C laser anneal** has a **40 % increased resistivity** as estimated with the same model.

5. Carrier profiling using µ4PP

- **New approach** cycling ion-beam sputtering and µ4pp to measure carrier profile.



- **Measure $R_S(z)$ with µ4pp → calculate ρ(z) → $N_A(z)$**
- A Gaussian shaped, **40 % active** dopant profile is obtained.



S. Folkersma, et al., IIT 2018 Proceedings, to be published

Conclusions

- µ4PP can be used to precisely (σ< 2%) measure the fin sheet resistance of nm-wide Si fins.
- For the implanted and annealed Si fins, **a width-dependent sheet resistance** was measured and explained by non-conductive or less conductive areas along the top of the fin sidewalls.
- The **active dopant profile** in these fins is Gaussian shaped with a 40 % dopant activation, as measured by µ4PP.

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