

Near-Surface Sub-nm Resolution Activation Profiles in P and Sb+P Doped Ge

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Motivation

- Ge is a promising channel material due to its high mobility, but it is difficult to make low resistance contacts to Ge NMOS
- Point defects in Ge behave p-type and reduce the active electron concentration

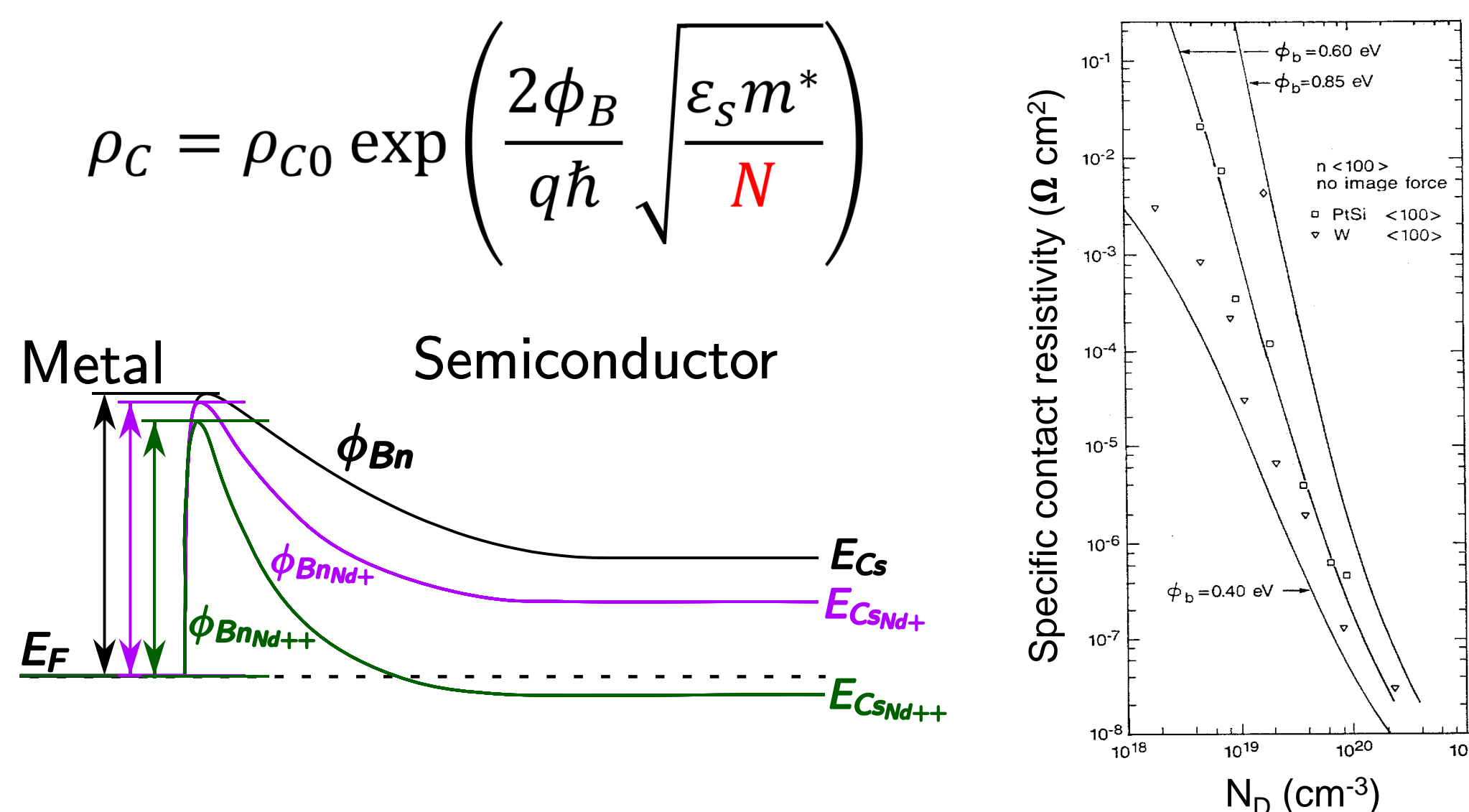


Fig. 1. Specific contact resistivity varies exponentially with surface active carrier concentration

Ge Co-Doping

- Co-doping of Ge with Sb and P reduces defect density in Ge and improves dopant activation
- Samples were prepared on epi-Ge to study the effectiveness of surface activation enhancement
 - P implant
 - Sb + P implant
- Implant conditions
 - Sb: $6 \times 10^{14} \text{ cm}^{-2}$ dose, 65 keV energy
 - P: $6 \times 10^{14} \text{ cm}^{-2}$ dose, 90 keV energy
 - Anneal: 500°C for 10 s in N_2

Dopant Activation Profiles

- The ALPro technology provides direct measurement of resistivity and mobility depth profiles and the associated carrier depth profiles based on the Differential Hall Effect Metrology (DHEM) technique
- SIMS was also done to compare chemical concentration to active dopant concentration

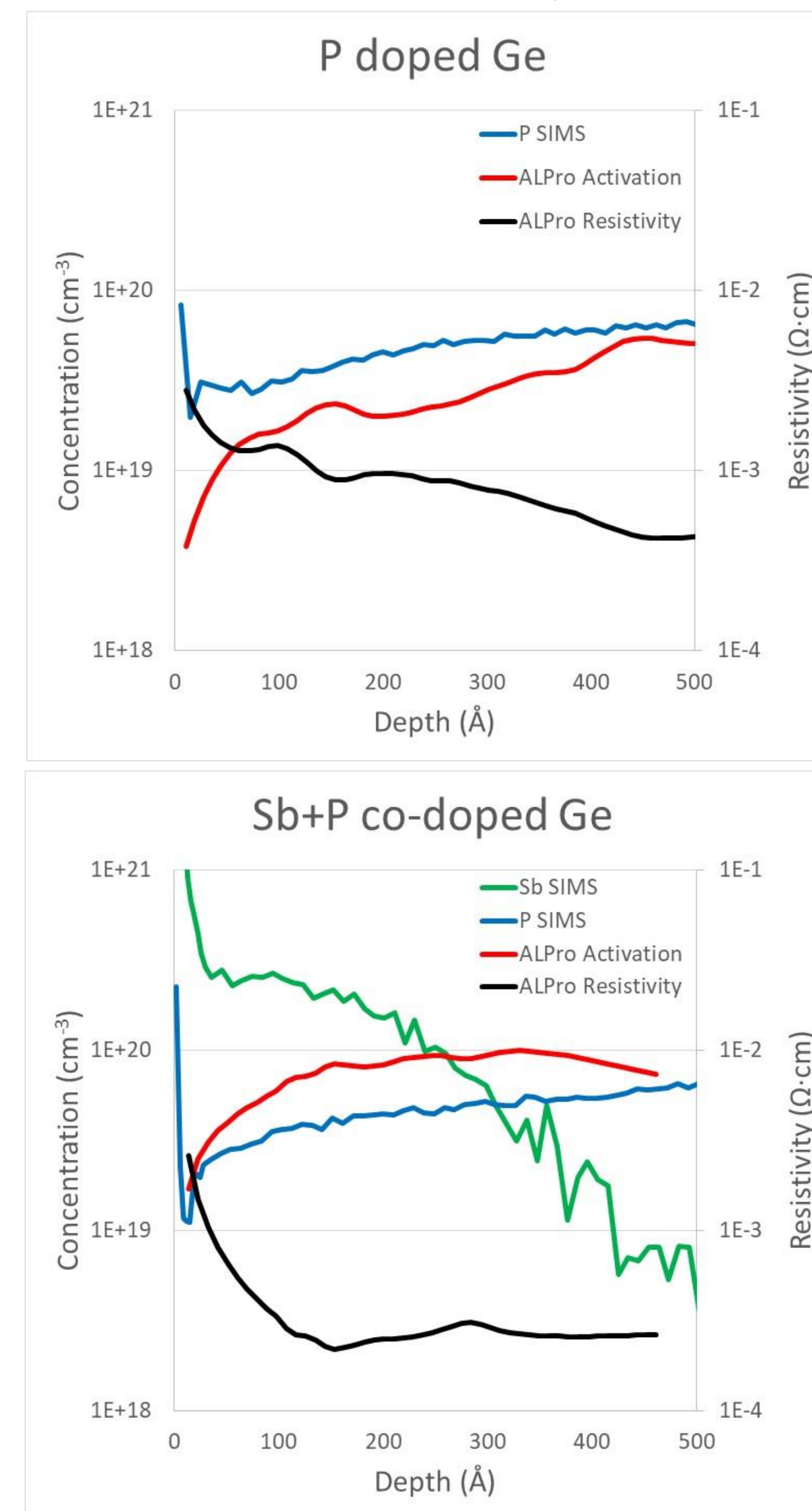


Fig. 2. ALPro and SIMS profiles in P doped Ge (top) and Sb+P co-doped Ge (bottom)

Conclusions

- In the P-doped sample surface active concentration is only 5% of the P chemical concentration
- Co-doping of Ge with Sb and P results in a 4x increase in the surface active electron concentration
- Both samples have bulk sheet resistance $\sim 40 \text{ } \Omega/\text{sq.}$ and drift mobility $\sim 275 \text{ cm}^2/\text{V}\cdot\text{s}$, indicating that bulk properties alone cannot be used to predict dopant activation level
- ALPro DHEM measurements provide activation, resistivity, and mobility profiles at sub-nm resolutions near the surface

Sample	Surface Active Conc. (cm^{-3})	Surface Chemical Conc. (cm^{-3})
P doping	5×10^{18}	1×10^{20}
Sb+P co-doping	2×10^{19}	1×10^{20} (P) 1×10^{21} (Sb)

Fig. 3. Summary of ALPro and SIMS surface data for P-doped Ge and Sb+P co-doped Ge

References

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