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Electrical property mapping of ZnO:Al films with micro four-point-probe technique

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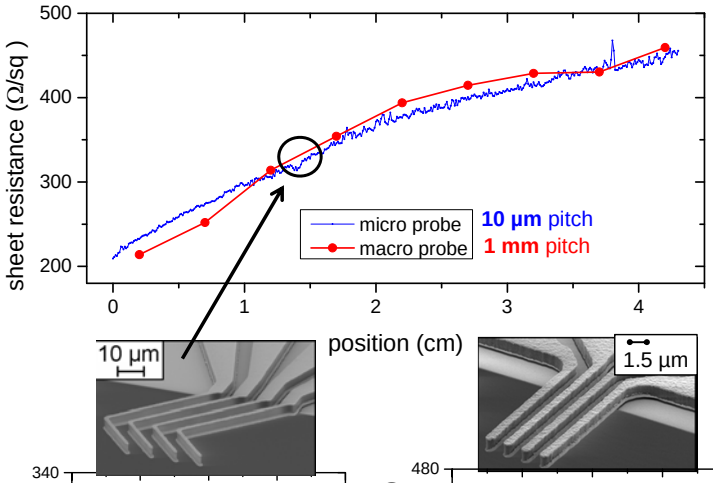
Motivation

Demonstrating the advantages of a **micro-four-point probe** setup for mapping electrical properties of transparent conductive films:

1. High spatial resolution
2. Non-destructive
3. Compatible with in-line processes
4. No sample preparation for Hall measurement
5. Error suppression by combining measurements from 7 probes

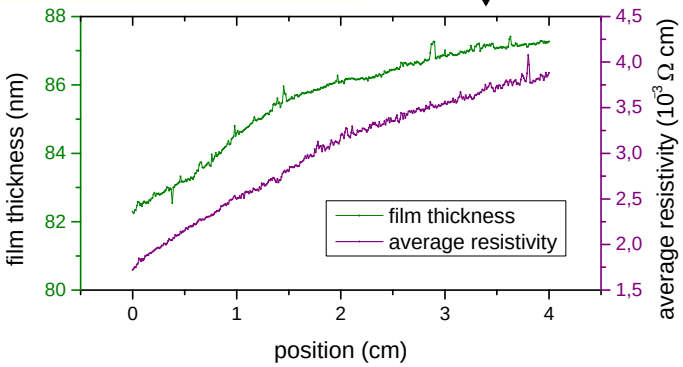
Sheet resistance measurement



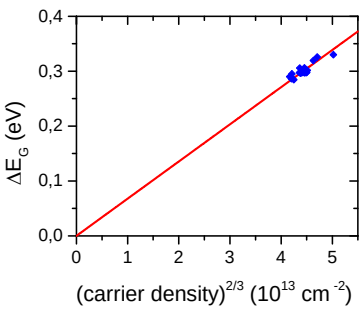
Probe with smaller pitch is more sensitive to local variations and reduces correlation effects

optical mapping (ellipsometry)

thickness



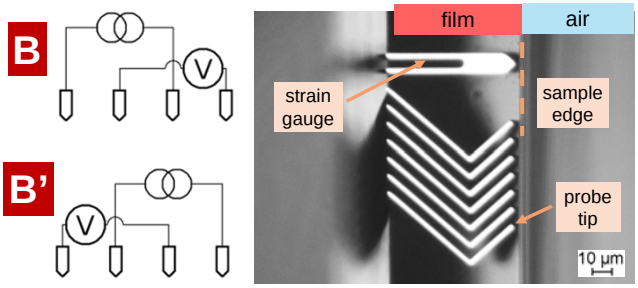
band gap

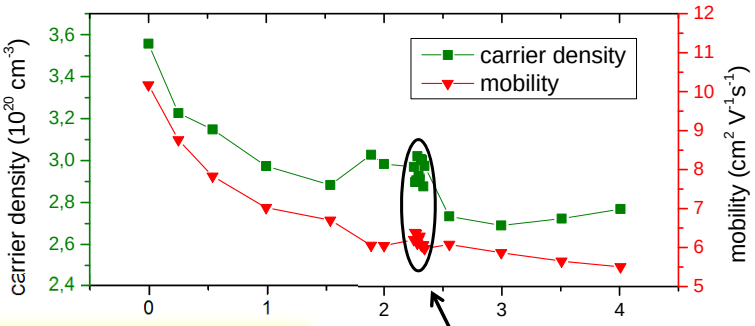


Hall measurement

measure V_B and $V_{B'}$ close to an insulating boundary

determine Hall mobility and carrier density



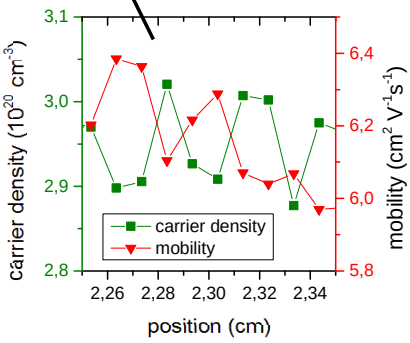


On a **~1 cm scale:**

Resistivity decreases due to increase in both carrier density and mobility

On a **~100 µm scale:**

carrier density and mobility vary in antiphase (measurement noise)



Burstein-Moss effect mapping:

$$\Delta E_G = \text{const}\left(\frac{1}{m_c}+\frac{1}{m_v}\right)n^{2/3}$$

ΔE_G: (optical band gap of ZnO:Al) – (band gap of undoped ZnO)

n: carrier density

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