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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

![Graph showing sheet resistance measurement for micro and macro probes with different pitch sizes.]

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

Hall measurement

- Measure $V_B$ and $V_{B'}$ close to an insulating boundary.
- Determine Hall mobility and carrier density.

B, B':

- Film and air.
- Probe tip.
- Sample edge.
- Strain gauge.

- Optical mapping (ellipsometry): thickness → optical mapping → band gap.
- Burstein-Moss effect mapping:

  \[
  \Delta E_g = \text{const} \left( \frac{1}{m_e} + \frac{1}{m_h} \right) n^{2/3}
  \]

  \[\Delta E_g: \text{ (optical band gap of ZnO:Al)} - \text{(band gap of undoped ZnO)}\]

  \[n: \text{ carrier density}\]

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