

# PHILIPS

A transient circuit-model for a phase  
change memory element

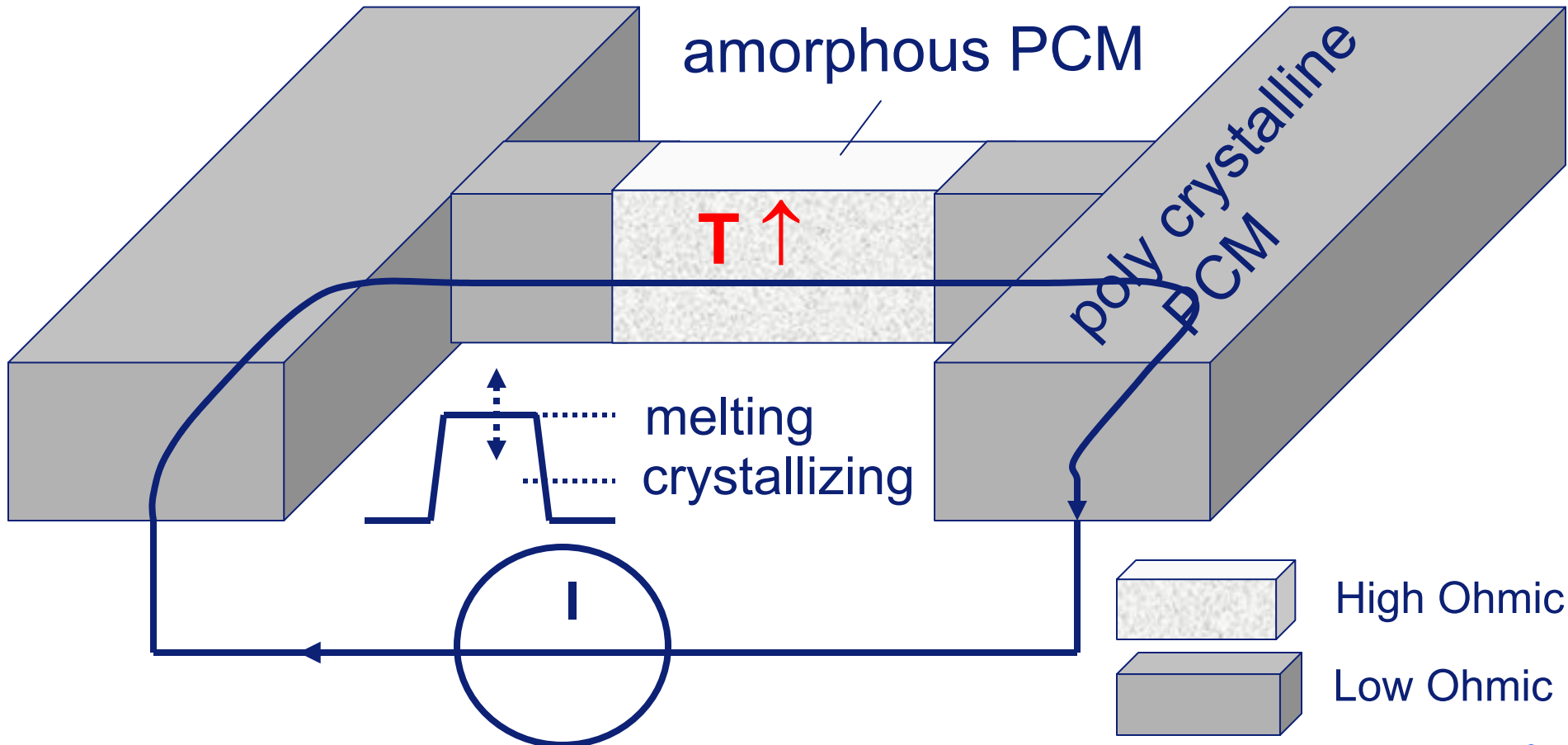
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# Motivation

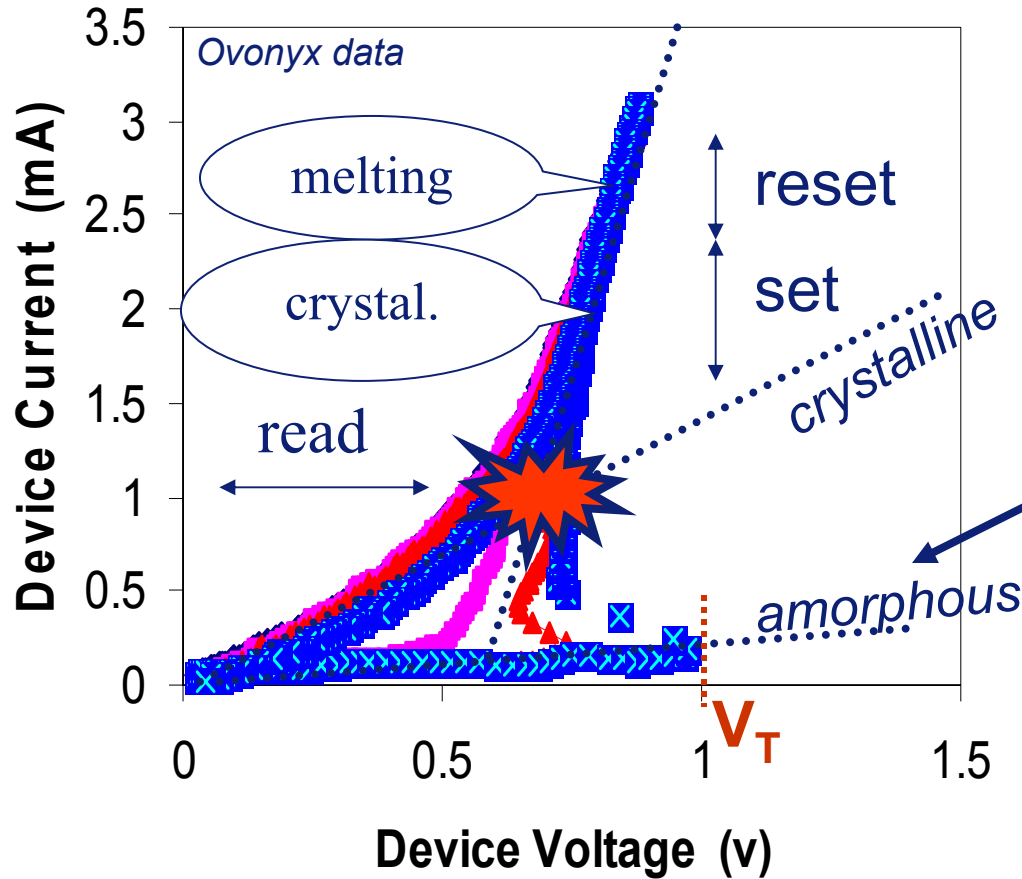
- Enable driver circuitry design of phase change memories
- Physics based model:
  - Relation with technology
  - Variability studies
  - scaling

# Line concept phase change memory cell

*growth-limited phase change material*



# I(V)-behavior: threshold switching

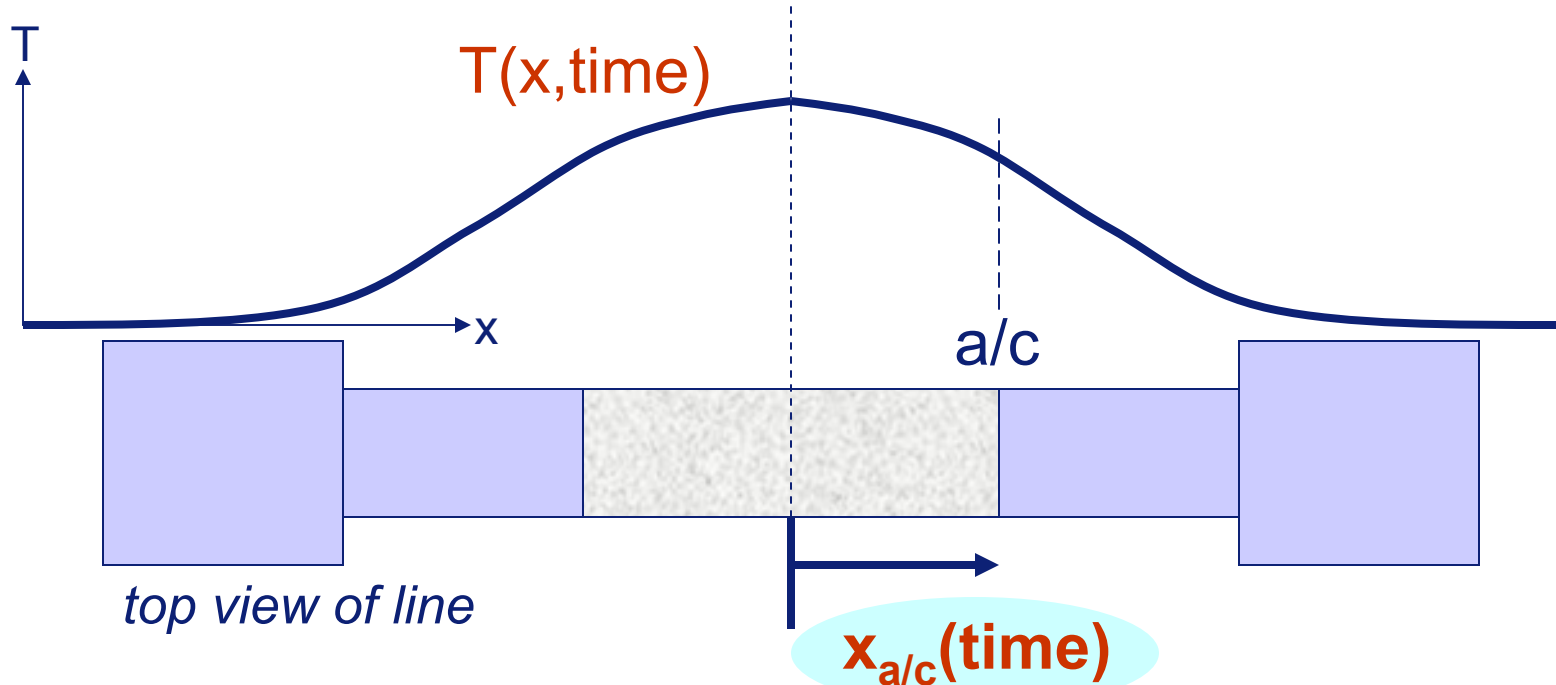


impact ionization  
 +  
 recombination  
 through traps  
 =  
 $V_T$

See e.g. Pirovano et al., 2004

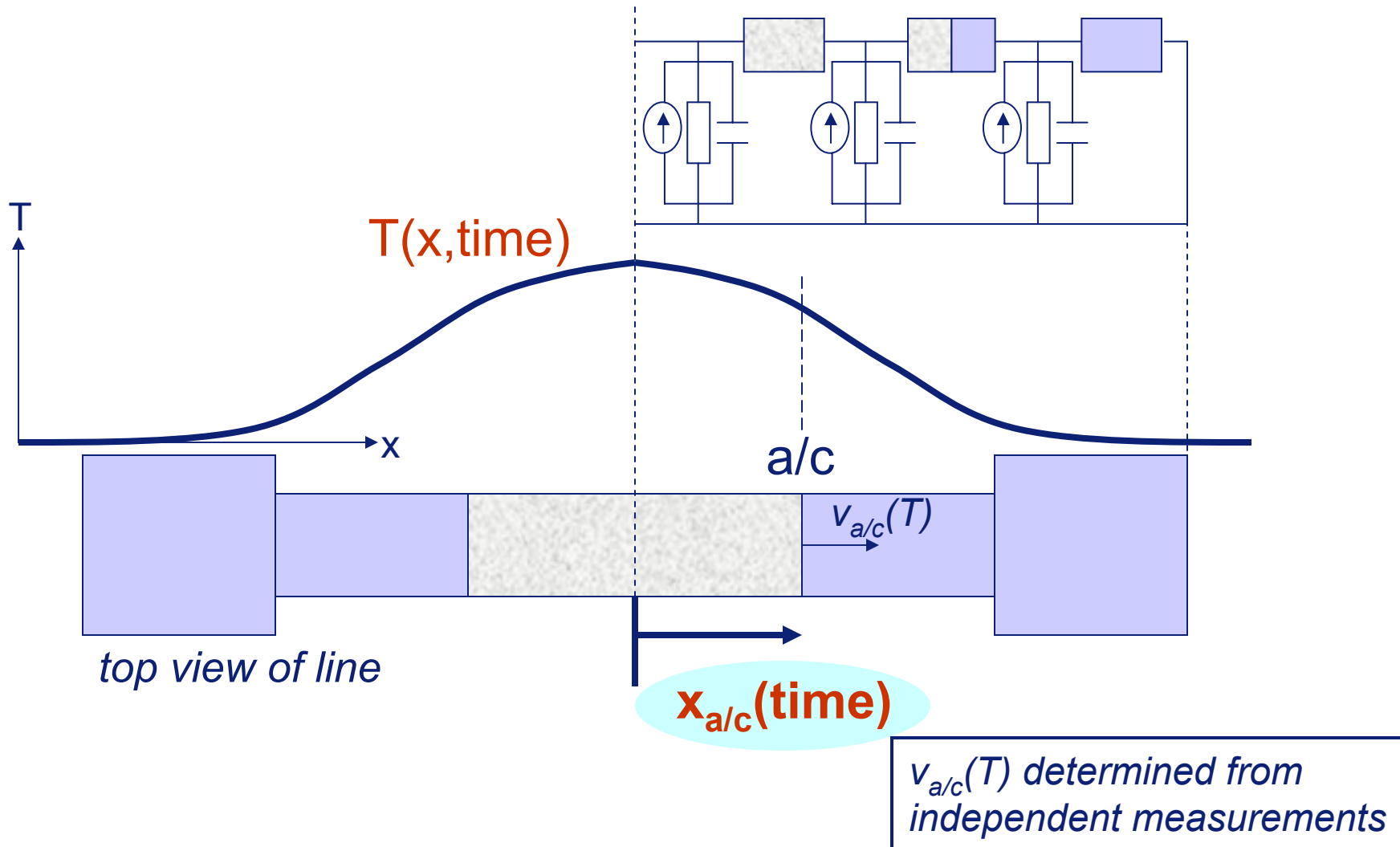
# Physics-based modeling approach: keep track of amorphous/crystalline interface

$$x_{a/c}(\text{time})$$



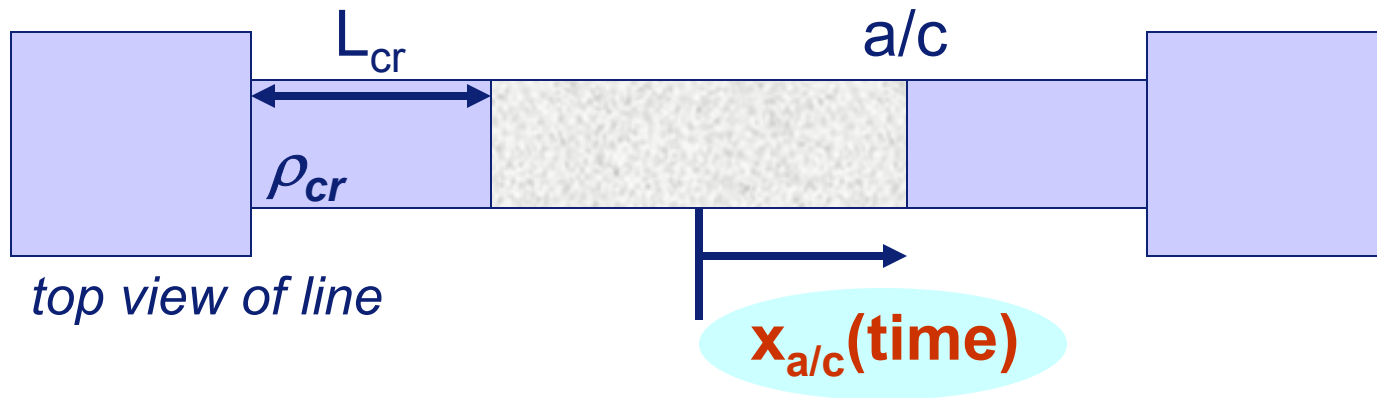
$v_{a/c}(T)$  determined from independent measurements

# Thermal model



# Electrical model

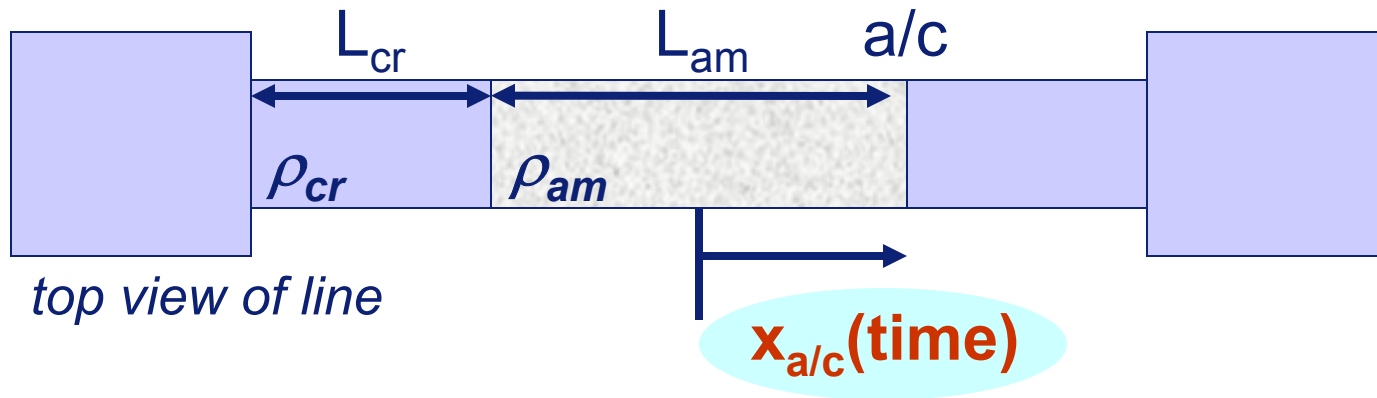
$$R_{cr} \propto \rho_{cr} \cdot L_{cr}$$



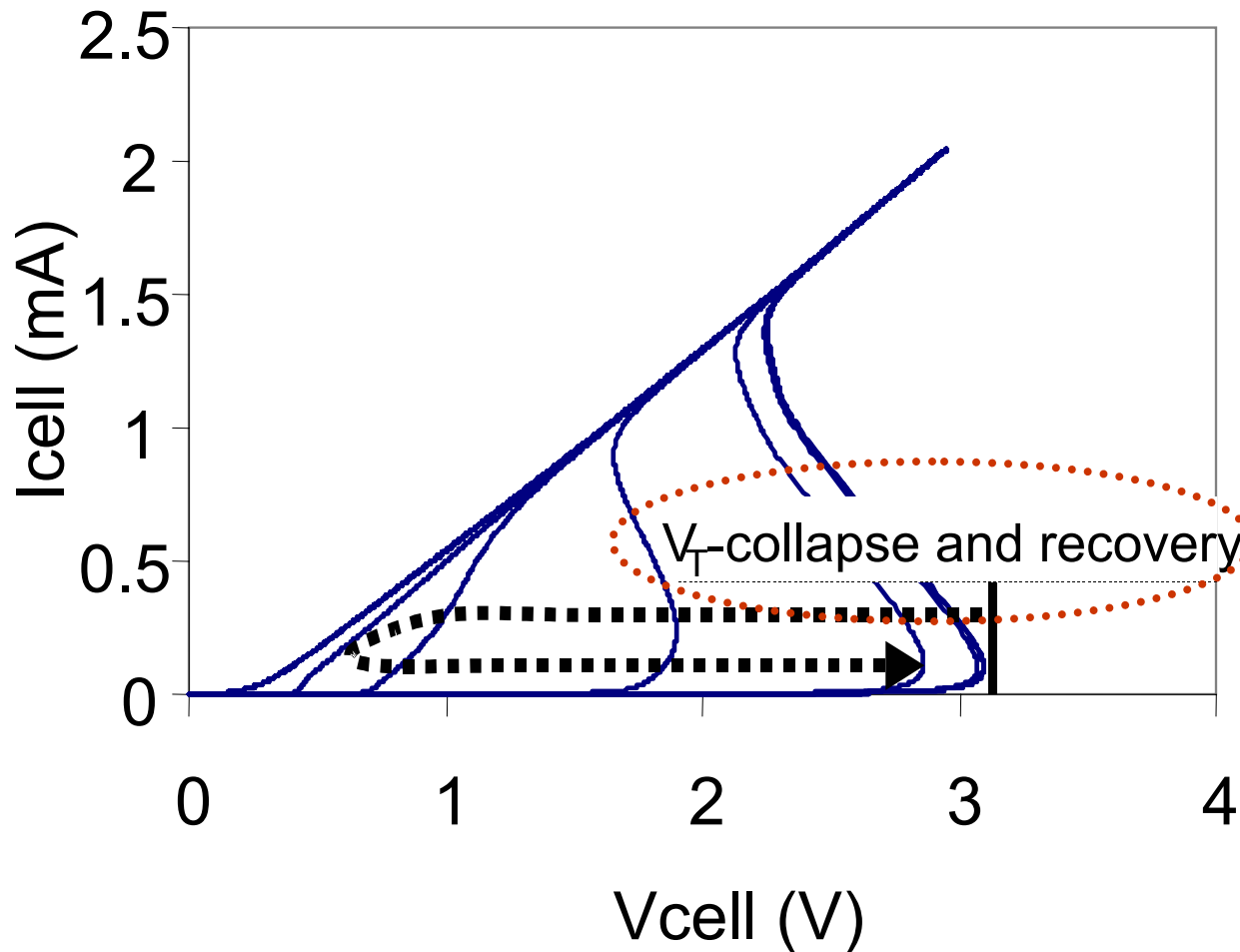
# Electrical model

$$R_{cr} \propto \rho_{cr} \cdot L_{cr}$$

$$R_{am} \propto \rho_{am} \cdot L_{am}$$



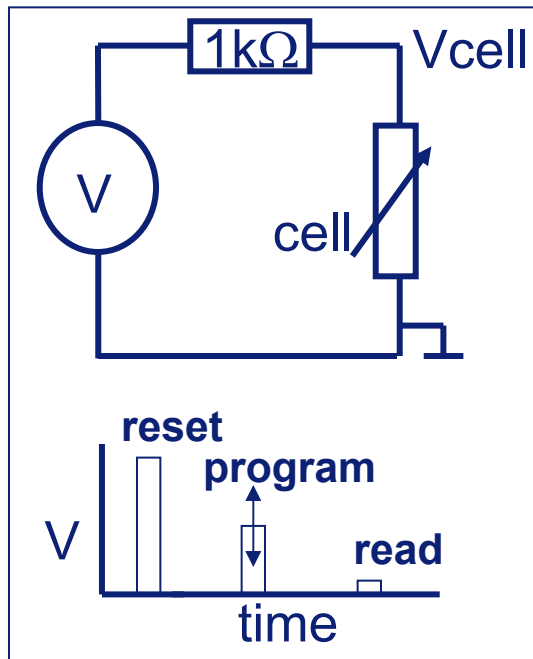
$\rho_{am}$  varies!



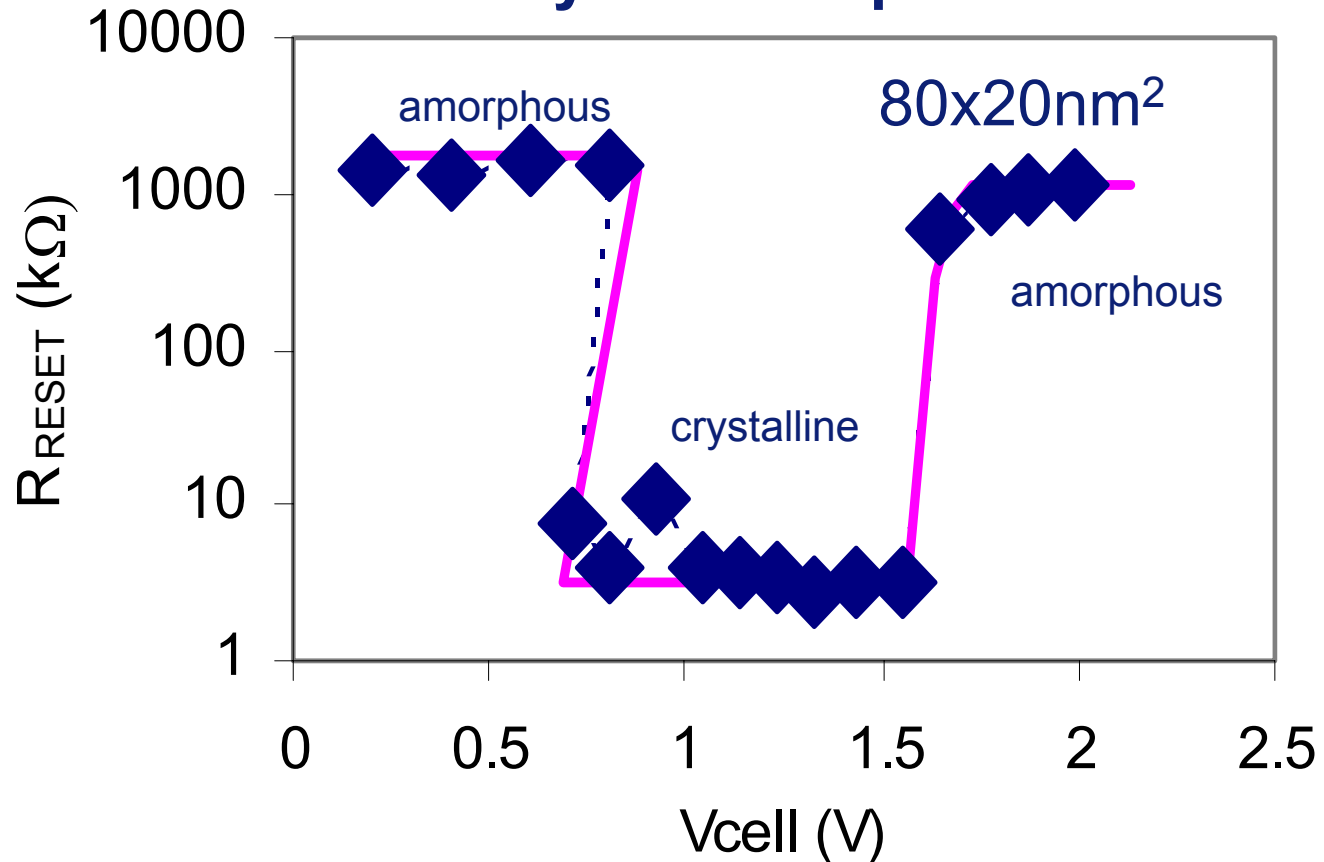
impact ionization  
+  
recombination  
through traps  
=  
 $V_T$

Traps depend on  
switching history  
 $\Rightarrow$   
 $V_T$  (and  $R_{am}$ ) drift

# Comparison simulations and measurements “programming curve”



Symbols: experiments



# Conclusion

- transient model
- “Threshold switching”
- $V_T$  (and R)-drift
- Parameters have physical meaning
  - Scaling, variability
  - Relation with technology
- Poster 62.53 I

