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Schottky-Barrier Diode Modeling Using VBIC

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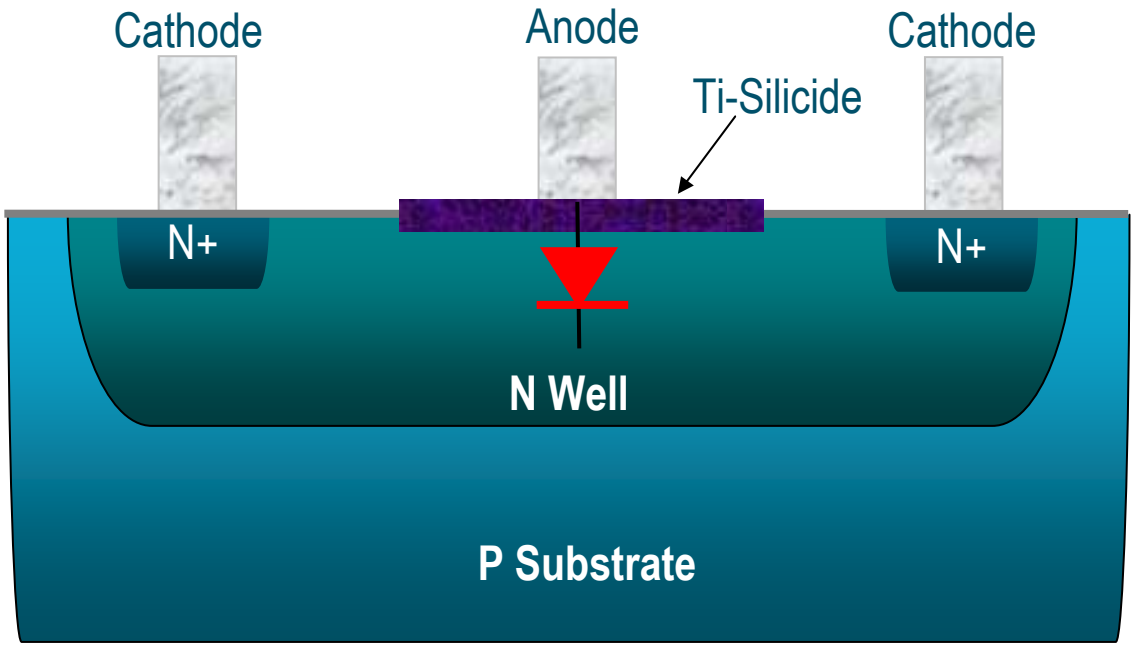
Bipolar Arbeitskreis, 15 October 2010, Crolles, France

Outline

- Schottky-Barrier Diode (SBD) cross-section
- Model Feature and Problem
- Model Network
- Simplified VBIC model for SBD
- DC Results
- CV Results
- Summary

Schottky-Barrier Diode Cross Section

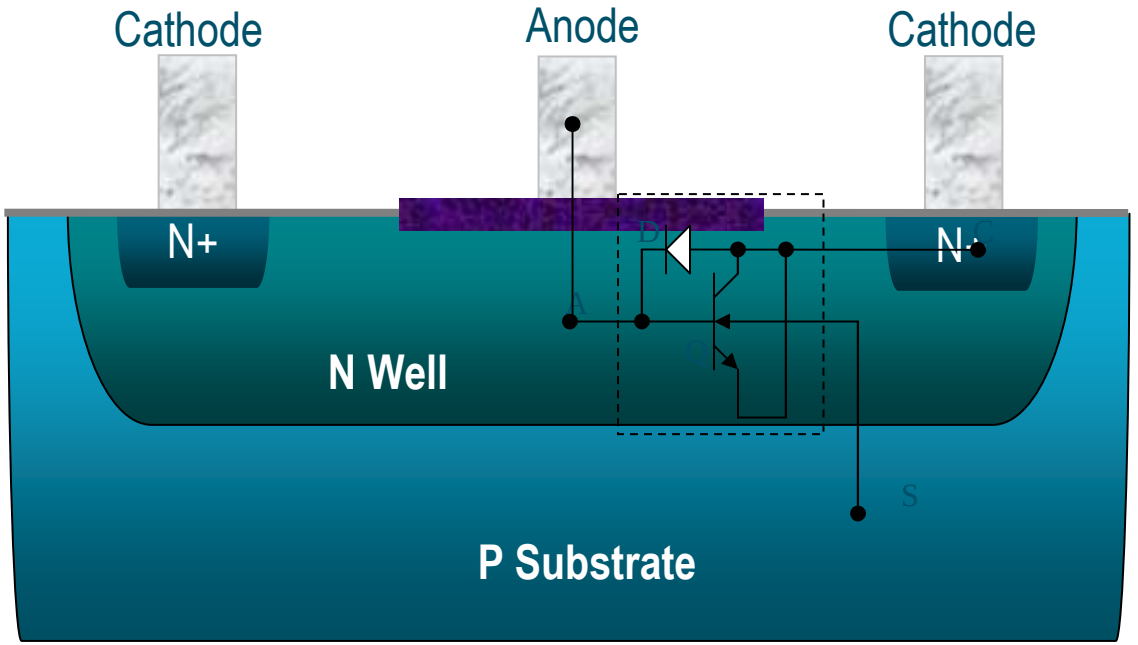


- Fabricated in CMOS 0.35 um process
- Making a Ti-Silicide contact in Nwell for Schottky Barrier junction
- Different geometry (variable length but fixed width)

Model Feature and Problem

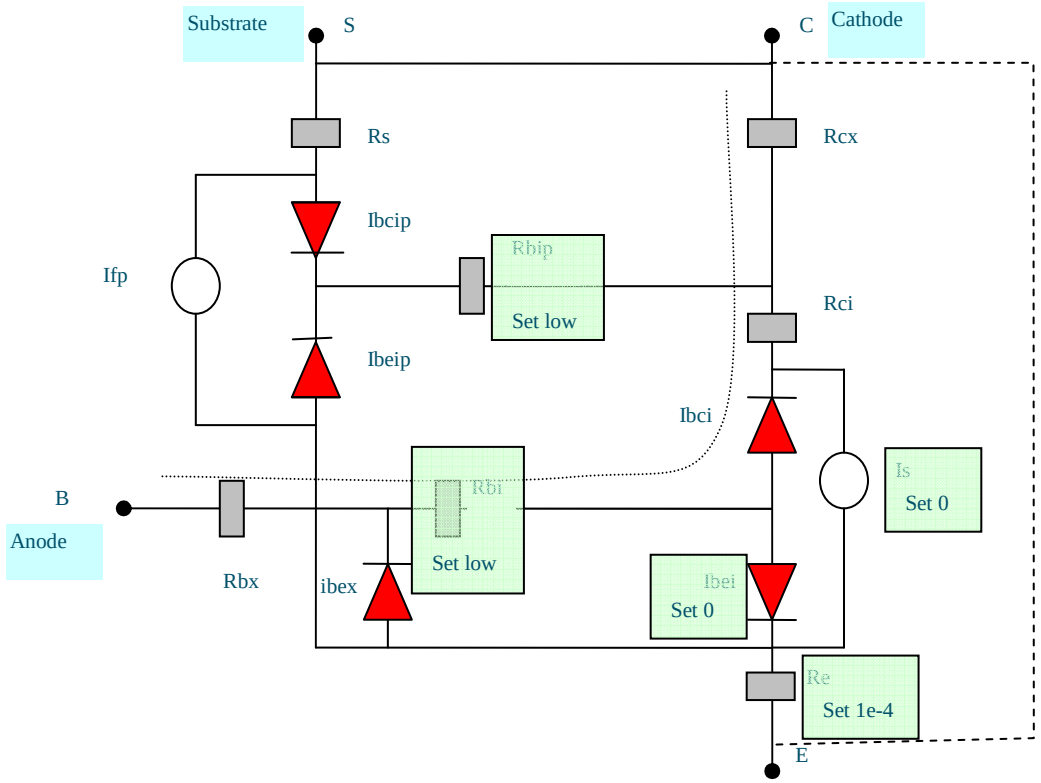
Physical Effects	Diode	1st Diode for SBD + 2nd Diode for substrate	PNP Bipolar SGP model	NPN Bipolar VBIC model	NPN Bipolar VBIC model + Diode
Forward SBD current	☑	☑	☑	☑	☑
Substrate current		☑	☑	☑	☑
Substrate current including injection			Less accurate	☑	☑
Bias dependent reverse leakage current					☑
Capacitance for SBD only	☑	☑	☑	☑	☑
Capacitance for SBD and substrate		☑	☑	☑	☑

Model Network



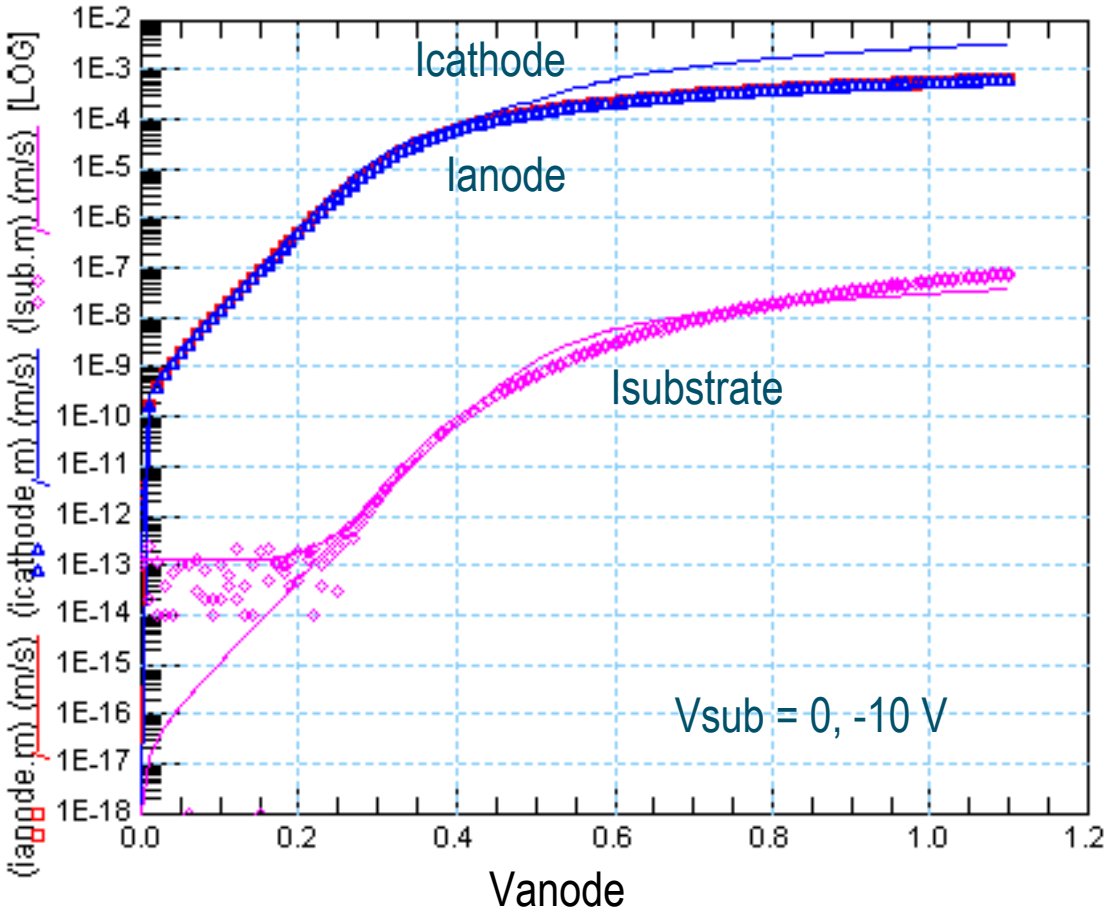
- NPN Bipolar VBIC model (Anode = Base, Cathode=Collector, Substrate = Sub)
- Added extra Diode (Anode – Cathode) for bias dependent leakage current
- Emitter is shorted to collector terminal

Simplified VBIC Model for SBD



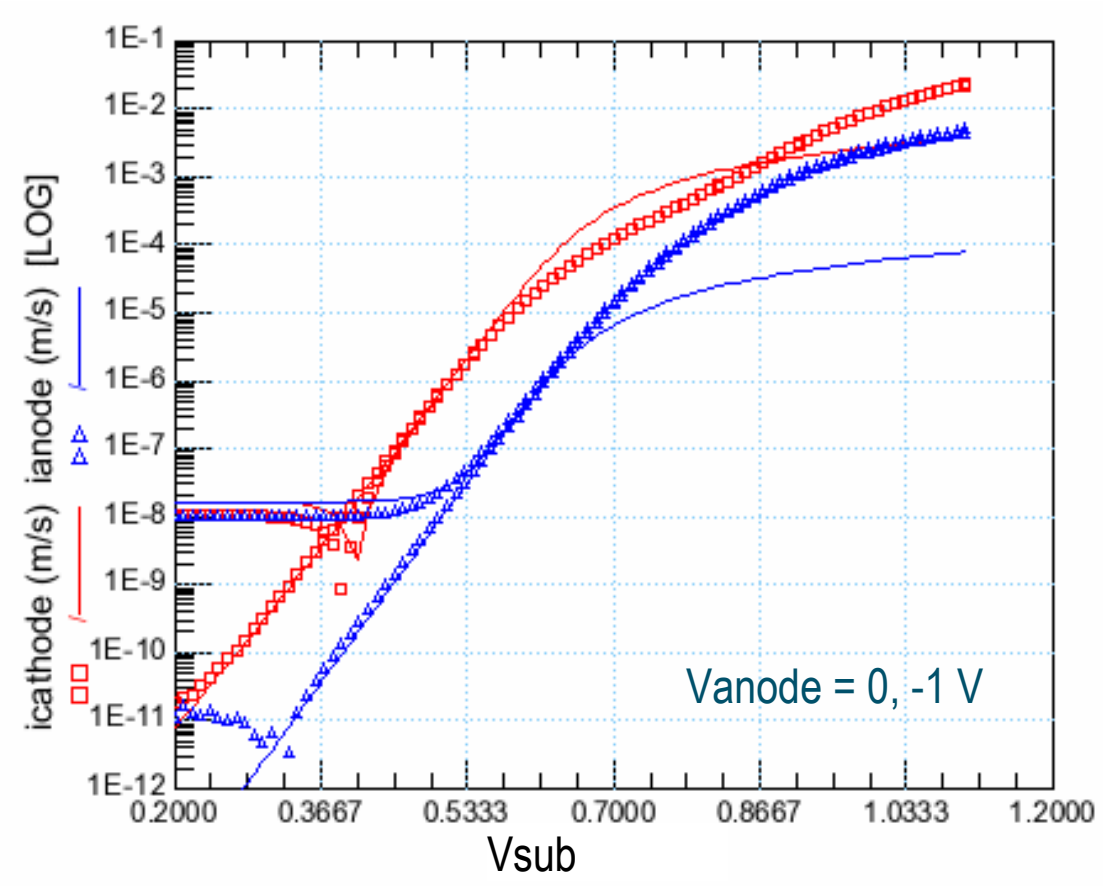
- Used parasitic PNP of main NPN VBIC model
- Very small value of some model parameters has been set in order to make no significant impact in the SB-diode behavior

Forward Characteristic



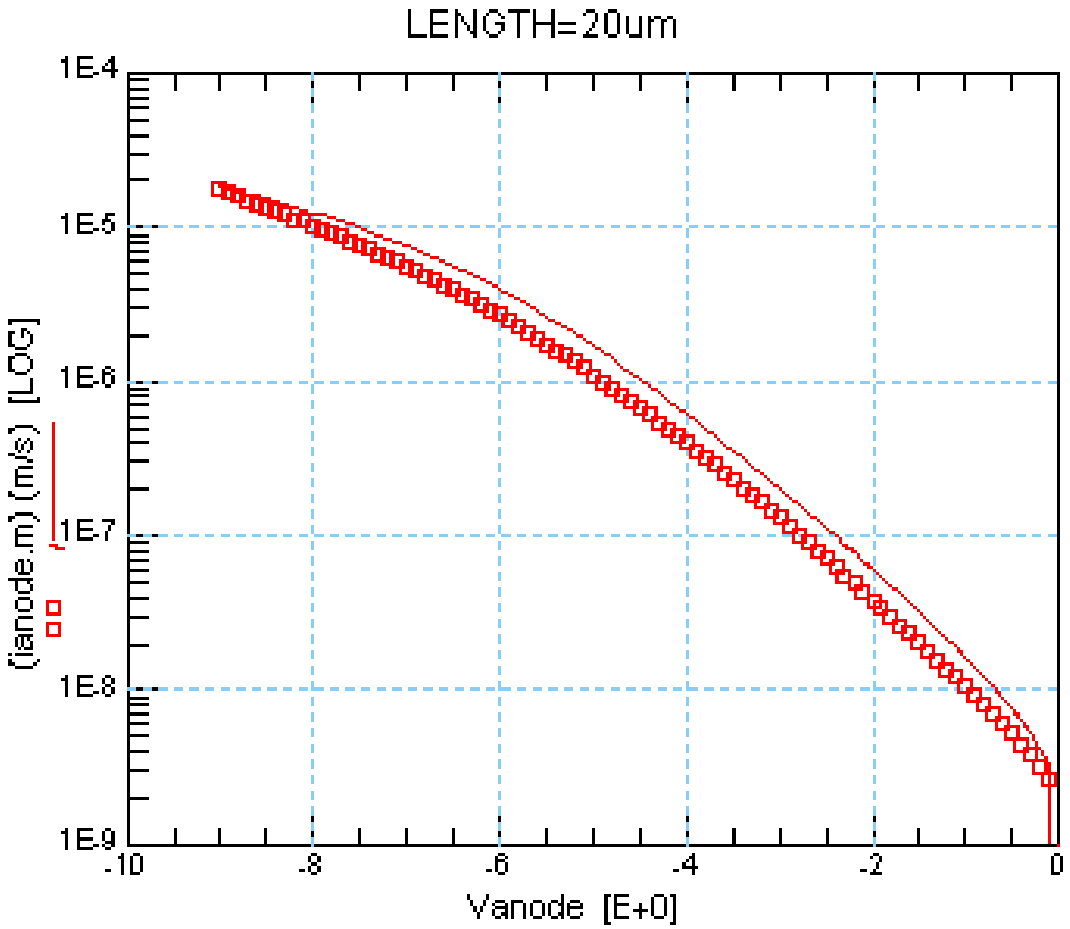
Characteristic	VBIC Parameter
Anode Current	IBCI RCI RCX
Substrate Current	ISP NFP IBEIP IKP IBCNP

Substrate Bias Dependent

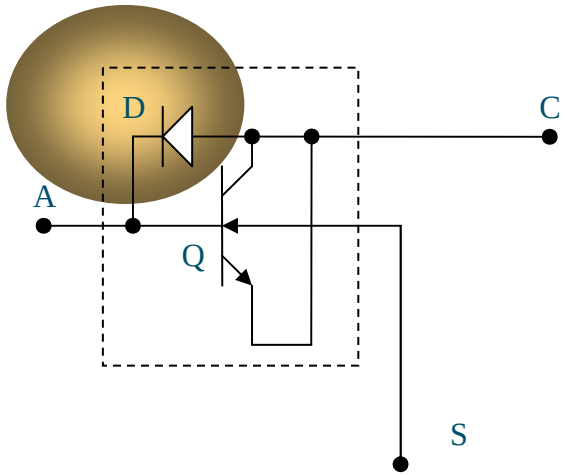


Characteristic	VBIC Parameter
Cathode Current	IBCIP NCIP

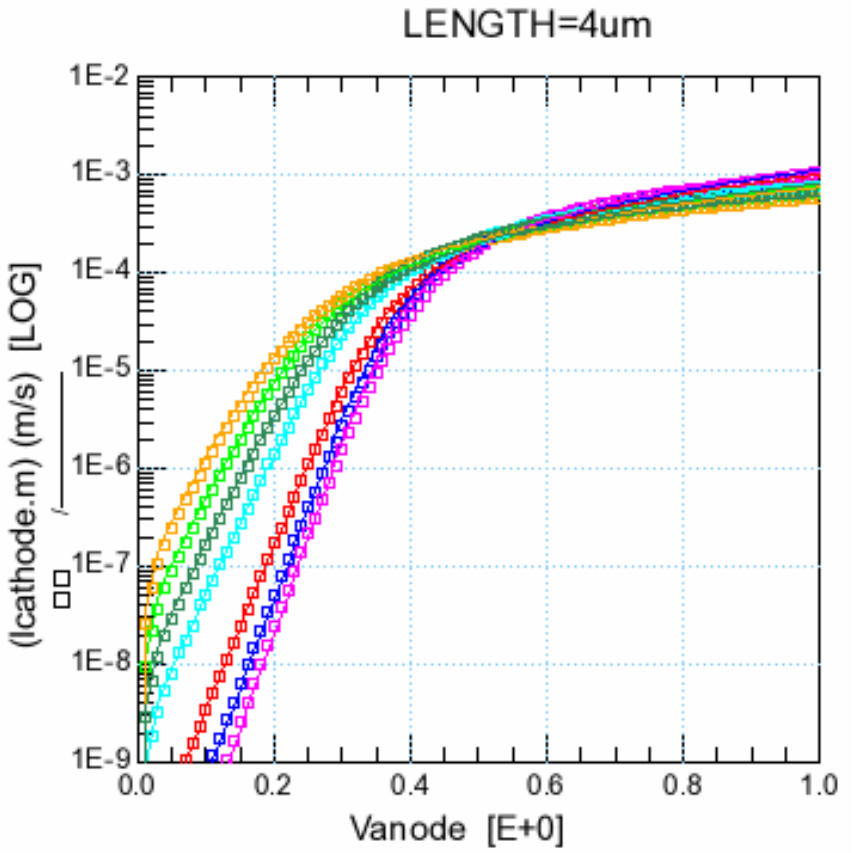
Bias Dependent Leakage Current



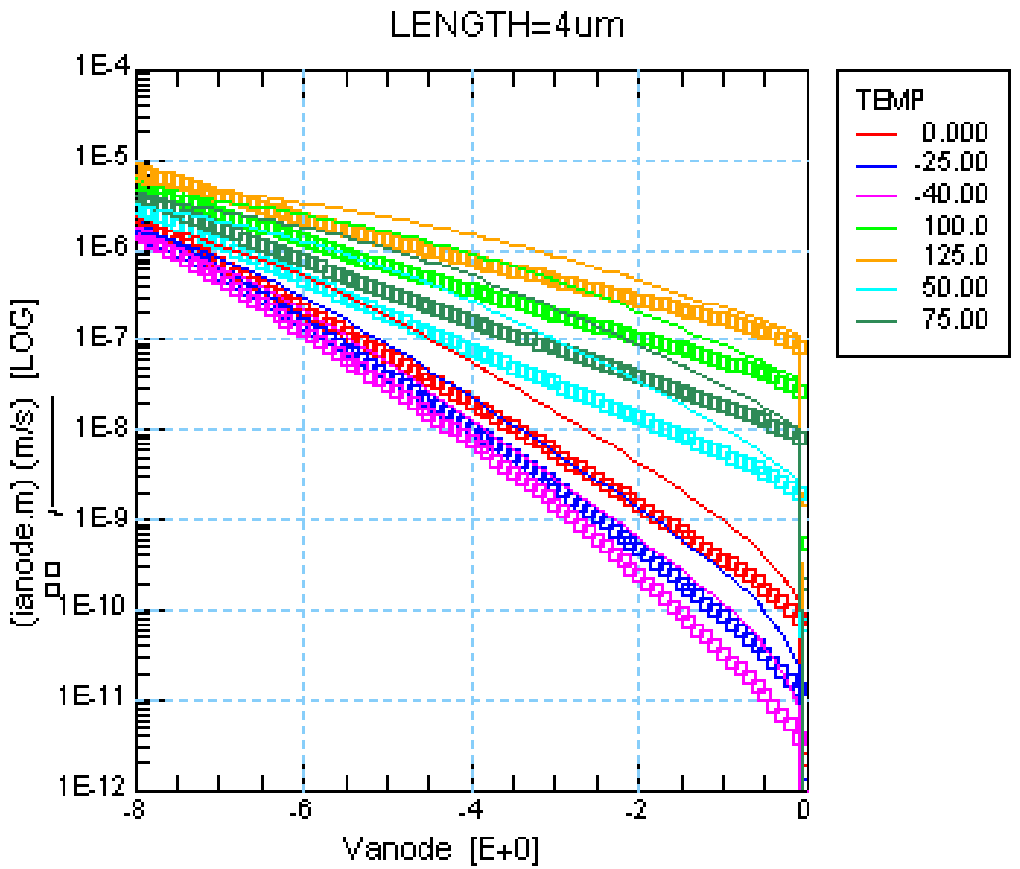
Characteristics	Diode Parameter
Anode/Cathode Current	IS
	N
	RS



Temperature Dependent Characteristics

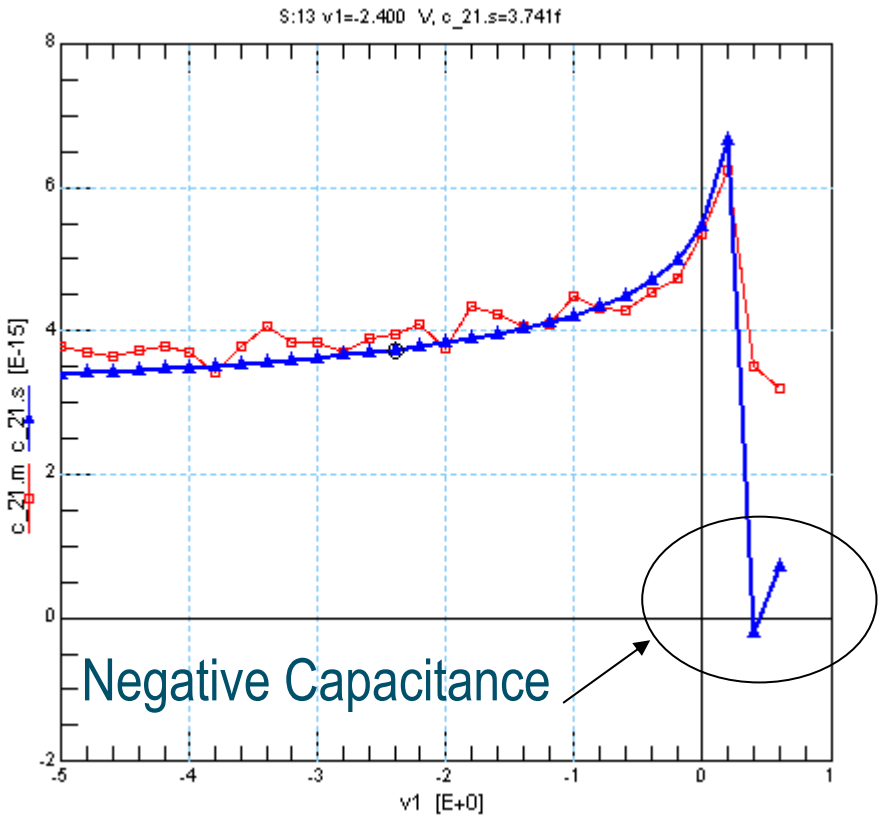


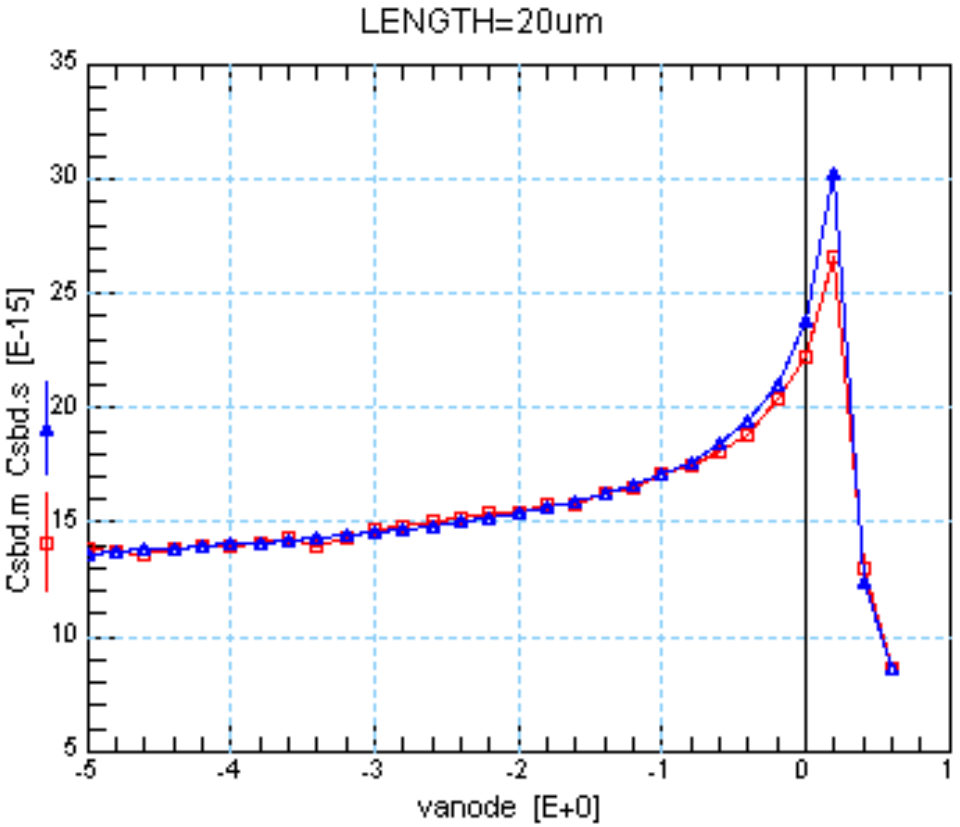
VBIC model parameters can predict temperature dependent forward current



While temperature dependent reverse leakage current can be modeled with Diode parameter.

Capacitance Model





- Simulation result shows negative capacitance value in forward bias.
- Used base-emitter capacitance together with base-collector capacitance in order to avoid negative capacitance

Summary

- Proposed a SPICE sub-circuit including VBIC bipolar transistor and a diode for accurate modeling of the Schottky barrier diode
- In particular,
  - forward current
  - substrate current
  - bias dependent leakage current
  - junction capacitance

  Has been modeled more accurately.