Updates on MOS Model 20, level 2002

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CMC, Oct 11th, 2006

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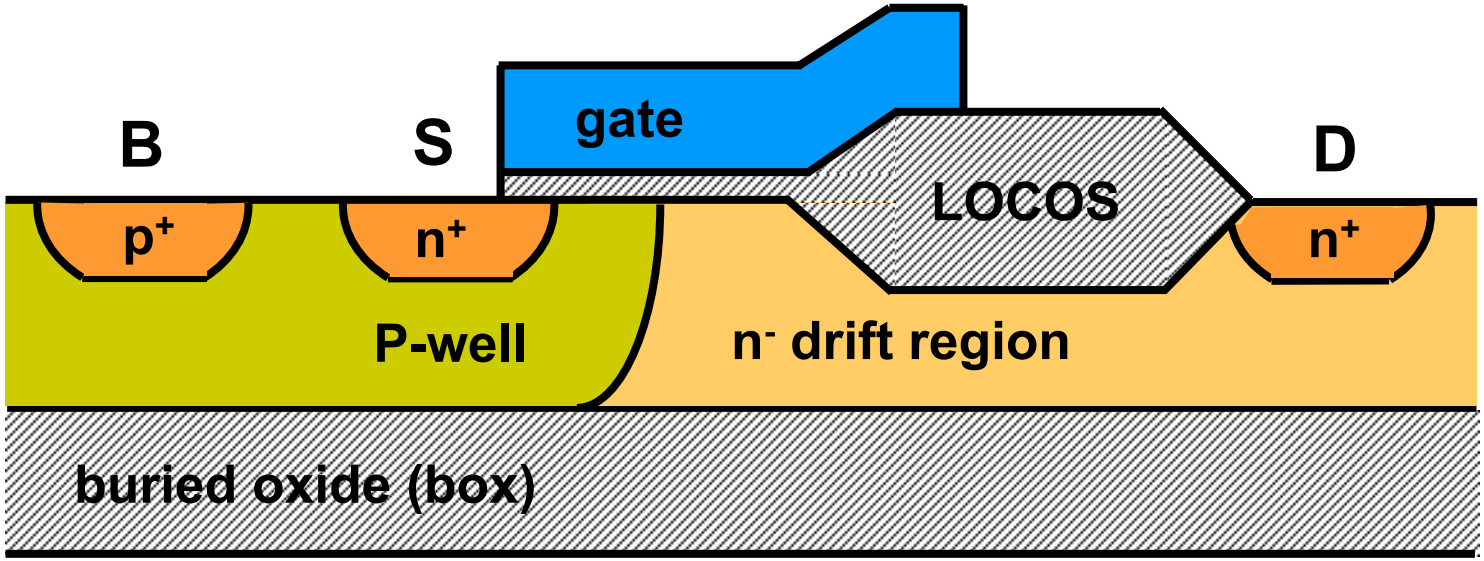
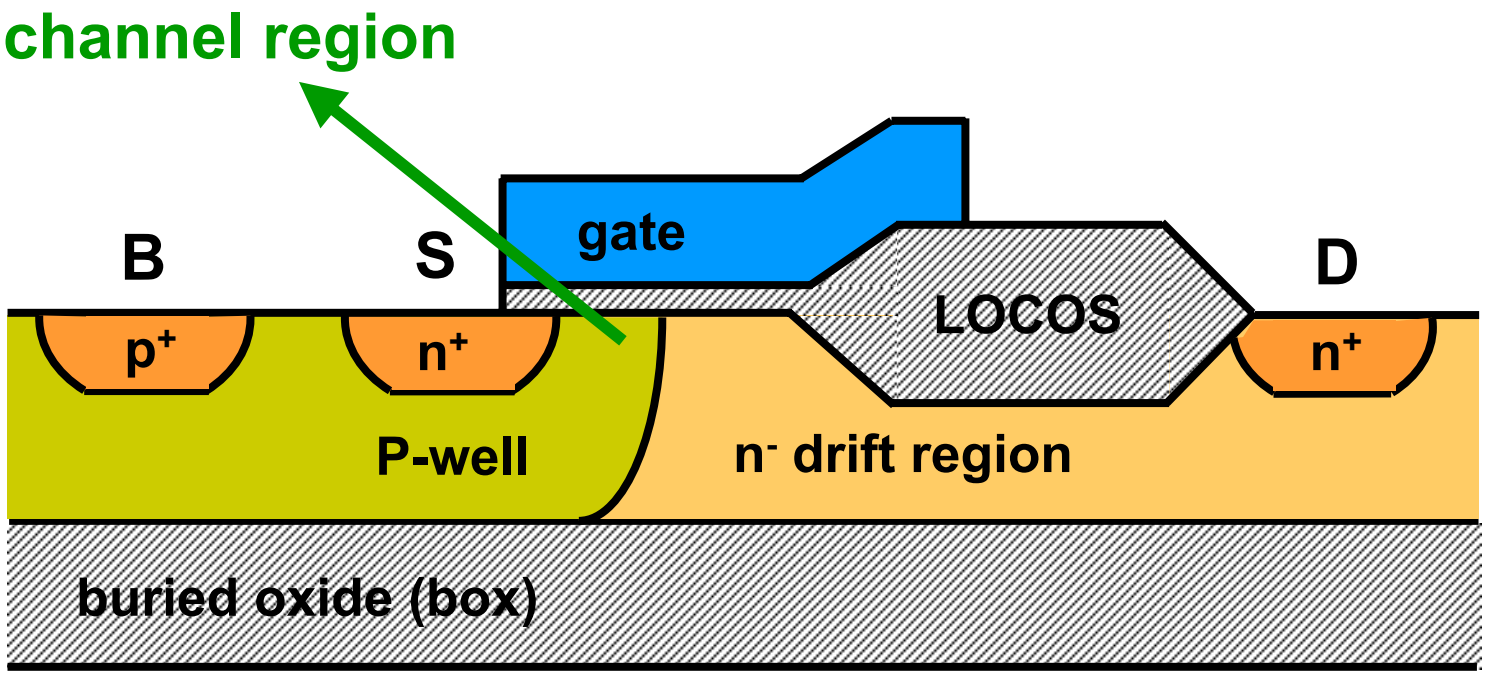
- introduction
- new avalanche current modelling
- update of C-code in SimKit
- update of model documentation
- future plans

introduction: (SOI-)LDMOS devices



introduction: (SOI-)LDMOS devices



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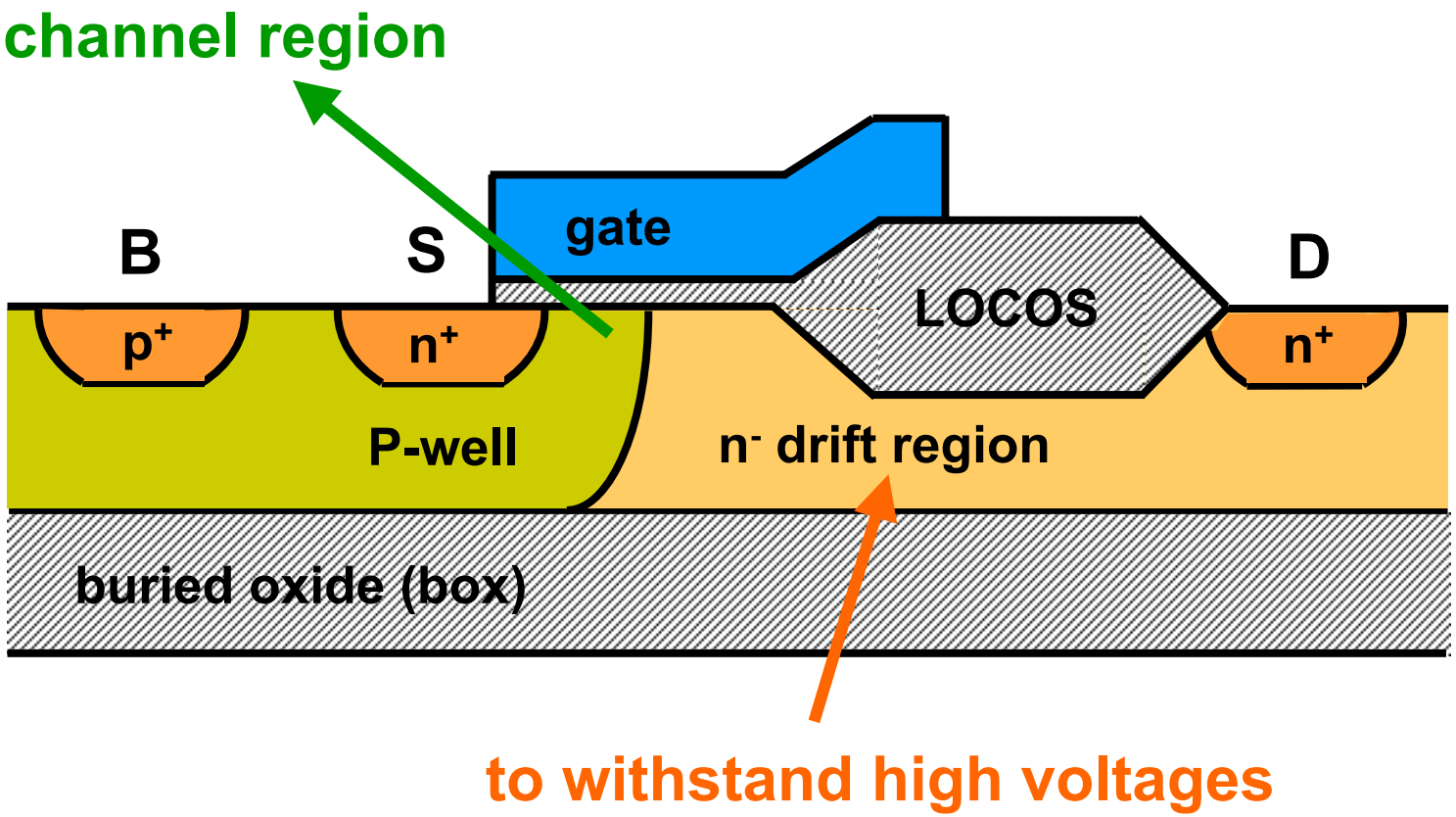

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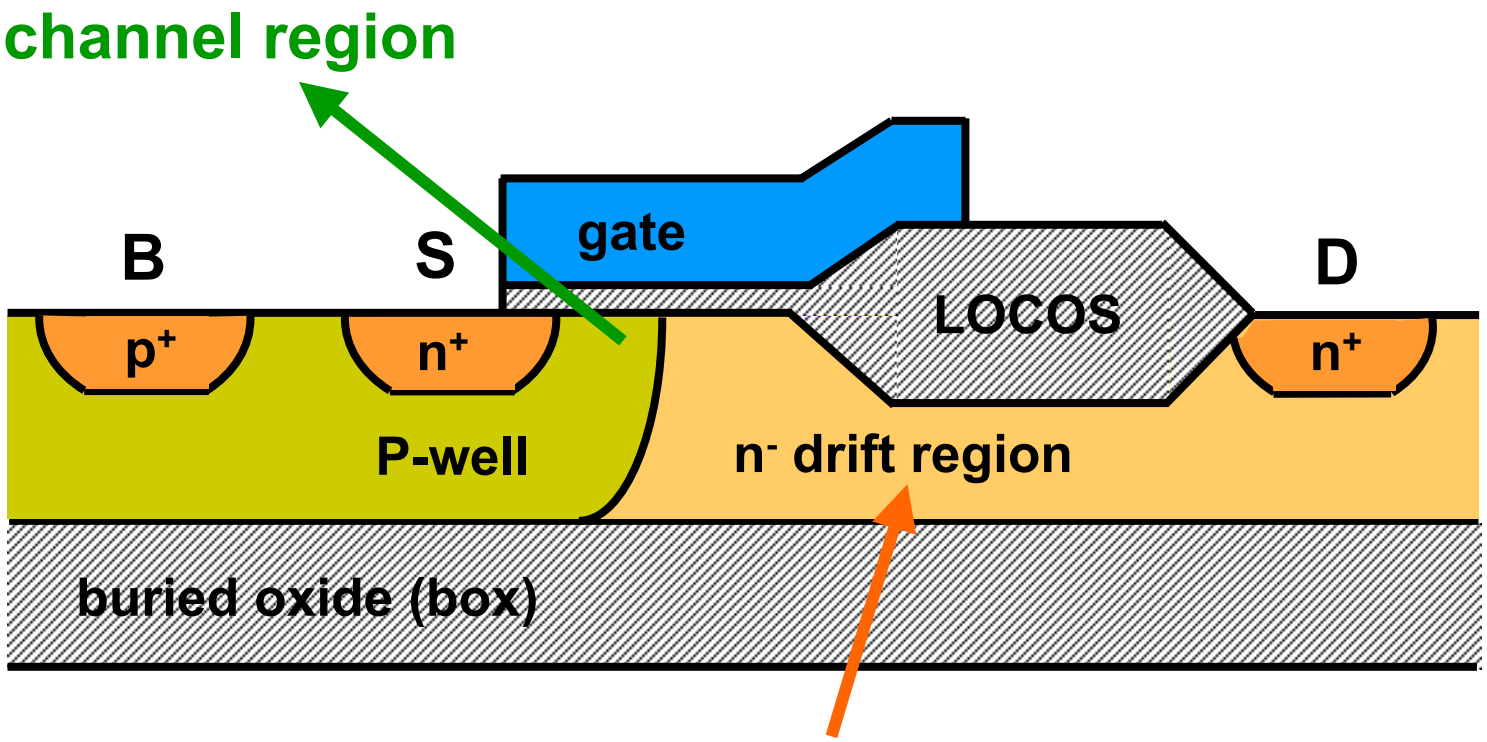
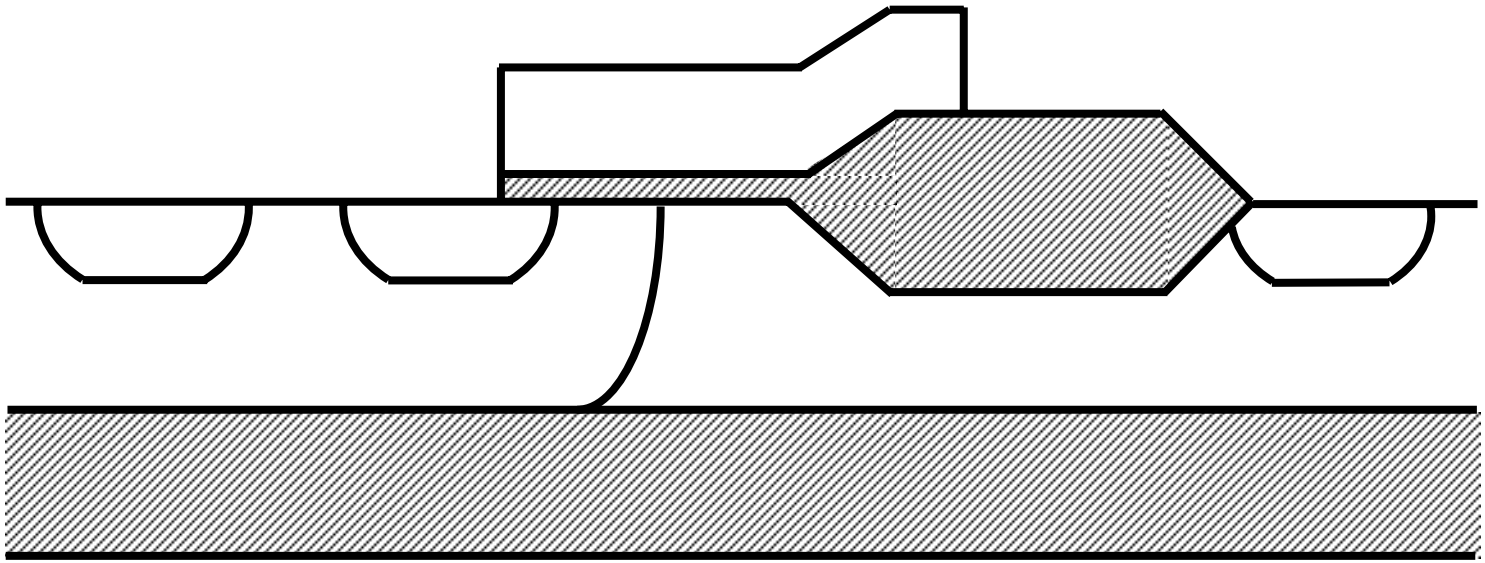


to withstand high voltages

drain voltages vary between 12 V and 1200 V

introduction: (SOI-)LDMOS modelling



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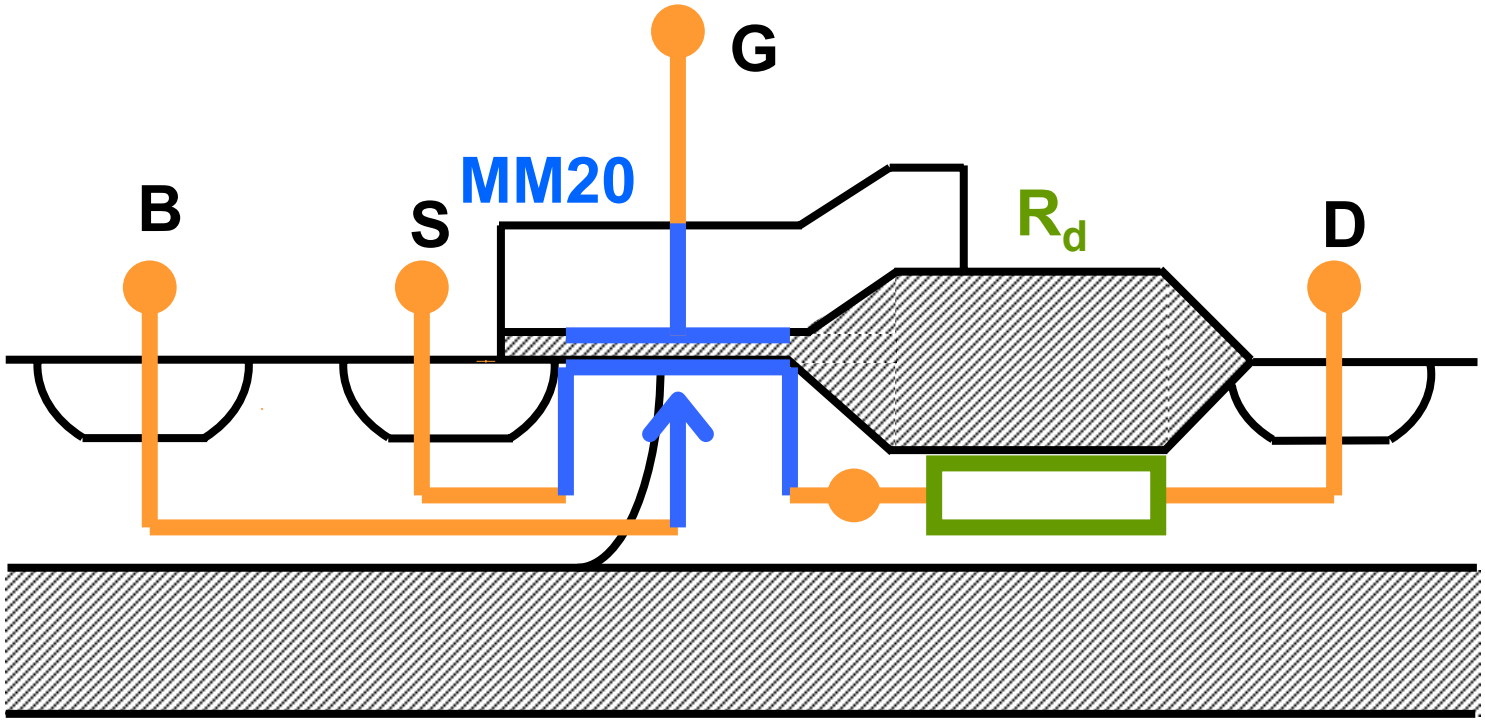

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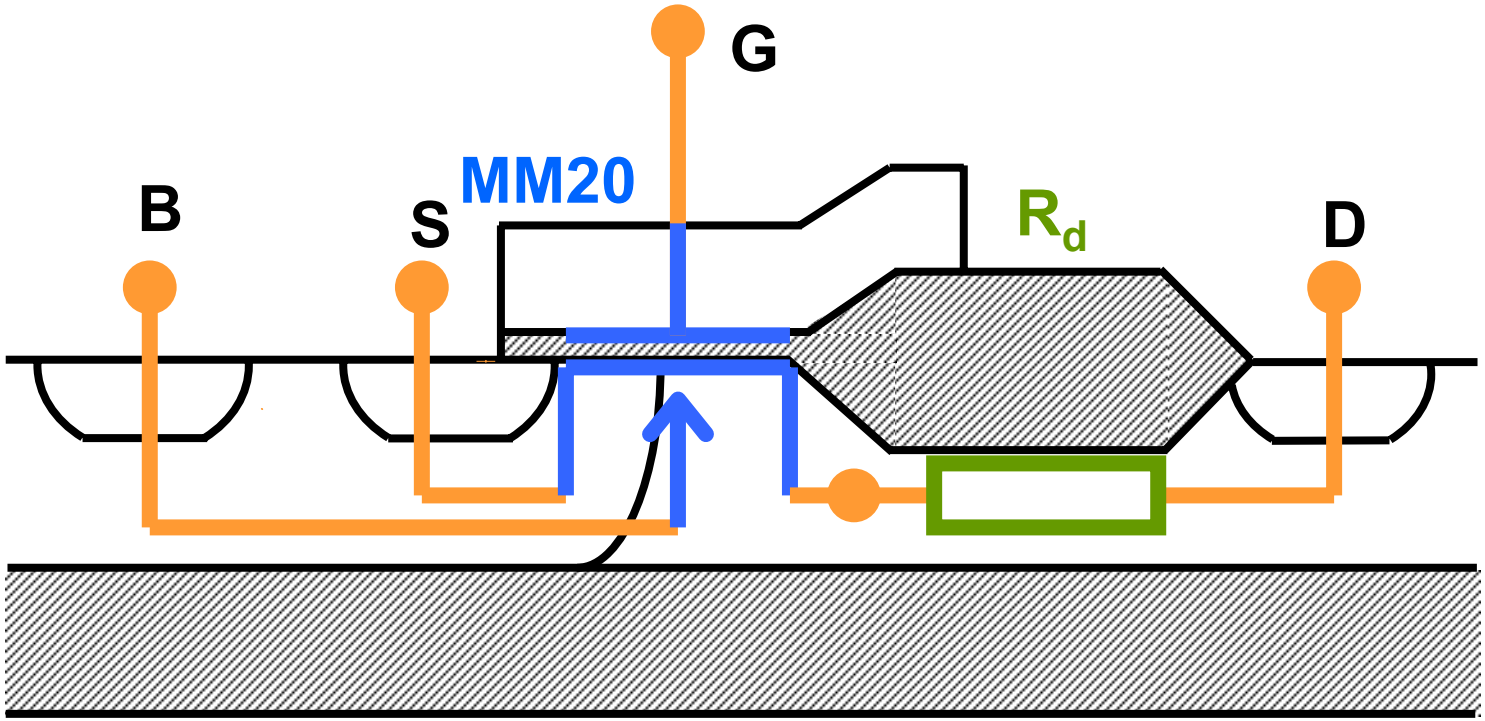

MOS Model 20 describes electrical behaviour of region under thin gate oxide of a high-voltage MOS device

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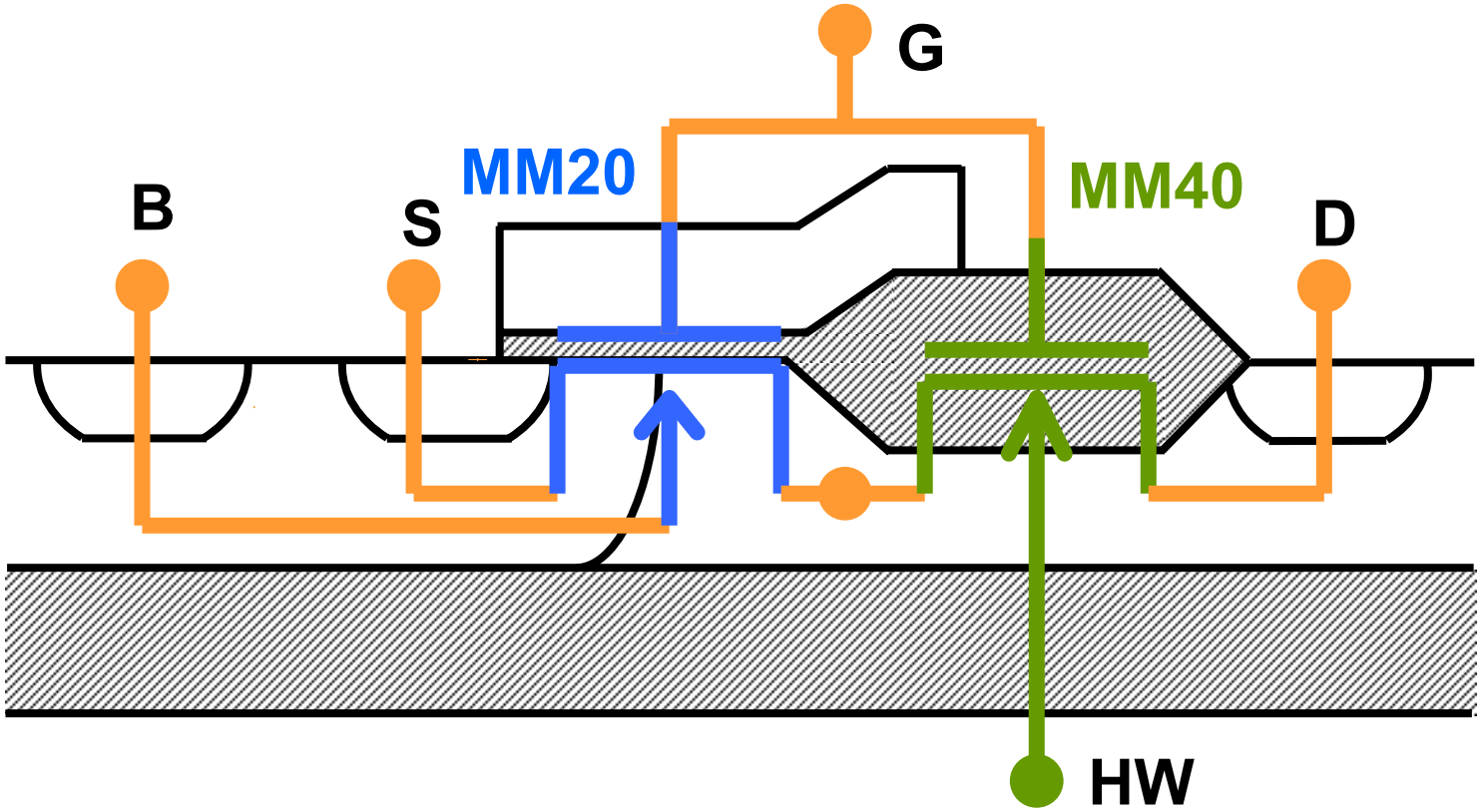

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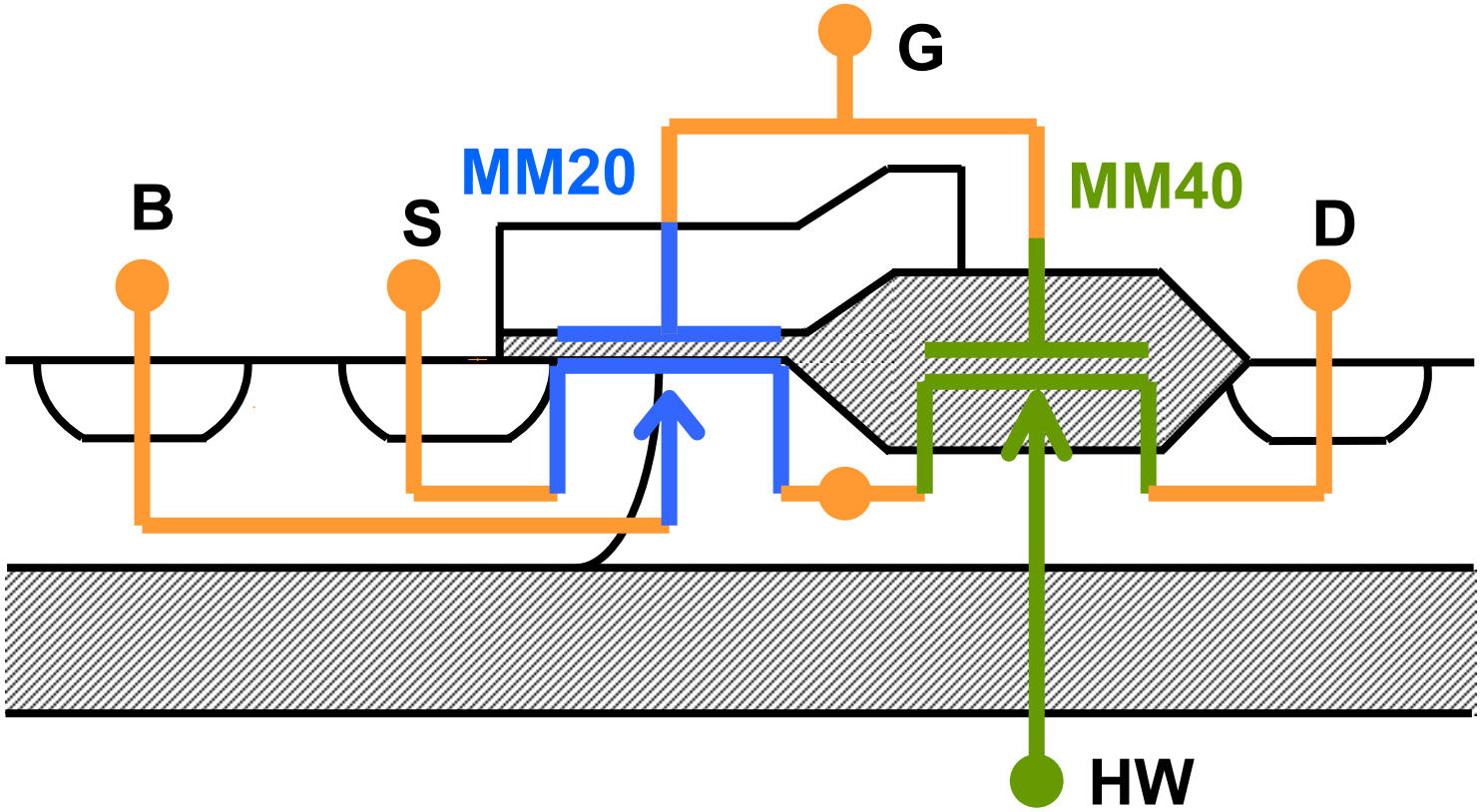
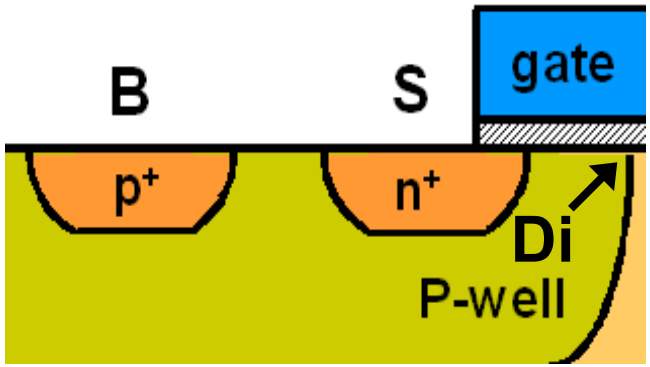
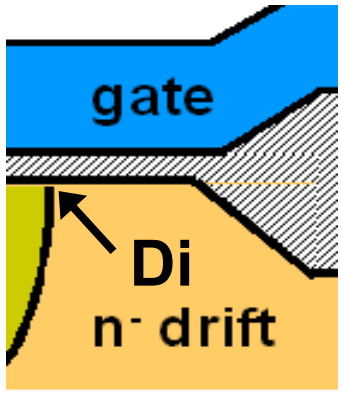


MOS Model 40 describes electrical behaviour of region under thick gate oxide of a high-voltage MOS device

introduction: MOS Model 20, level 2002





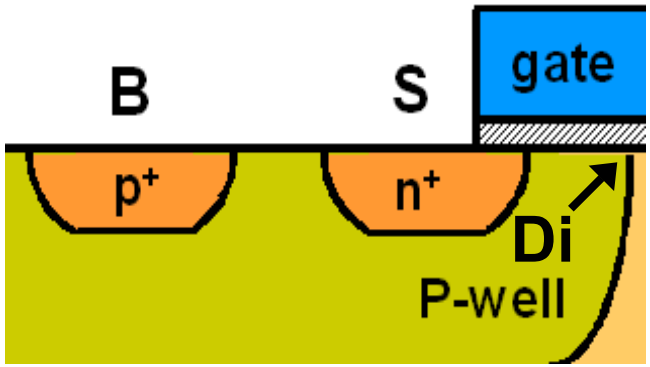
channel region:

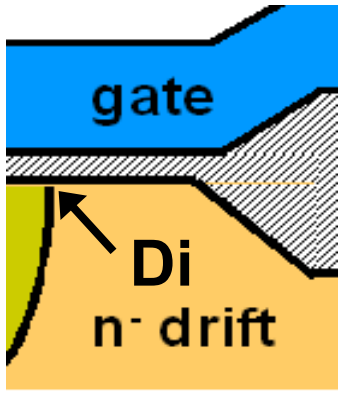
- surface-potential-based
- mobility reduction due to vertical electric field
- velocity saturation
- channel length modulation
- DIBL & static feedback
- avalanche

drift region:

- accumulation
- depletion
- bulk current
- mobility reduction due to vertical electric field
- velocity saturation

introduction: MOS Model 20, level 2002





channel region:

- surface-potential-based
- mobility reduction due to

drift region:

- accumulation
- depletion

for more information:

http://www.eigroup.org/cmc/minutes/2q06_presentations/cmc_mm20_www.pdf

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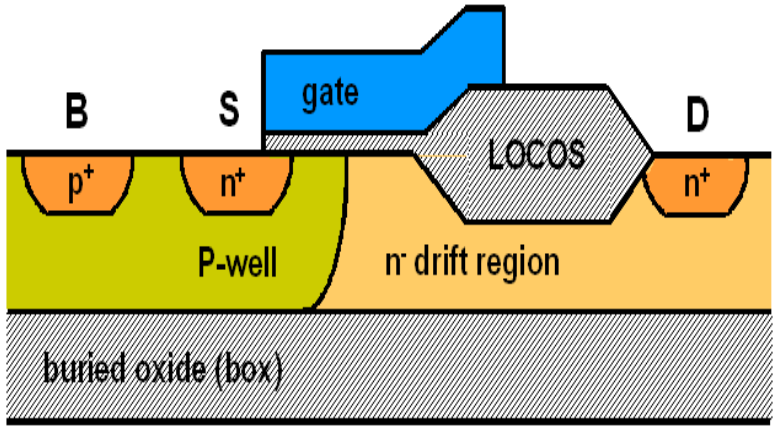
- new avalanche current modelling
- update of C-code in SimKit
- update of model documentation
- future plans

avalanche multiplication current
(history of problem)

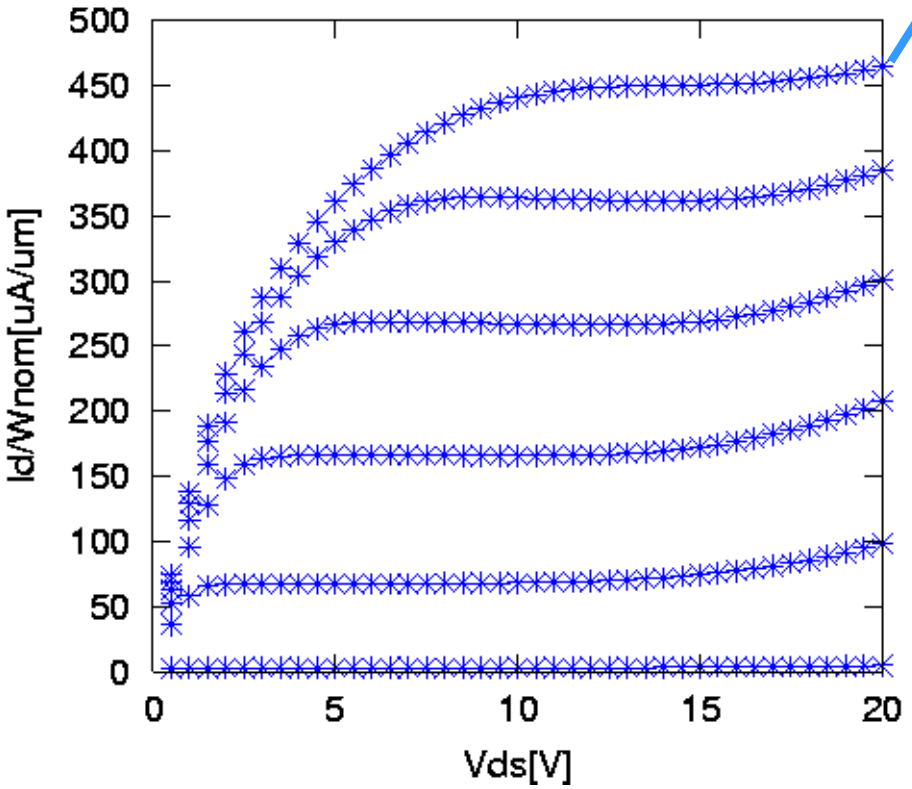
I-V characteristics



avalanche multiplication current
(history of problem)

I-V characteristics
Vgs=1/…/6 V

measured



avalanche multiplication current
(history of problem)

MM2002

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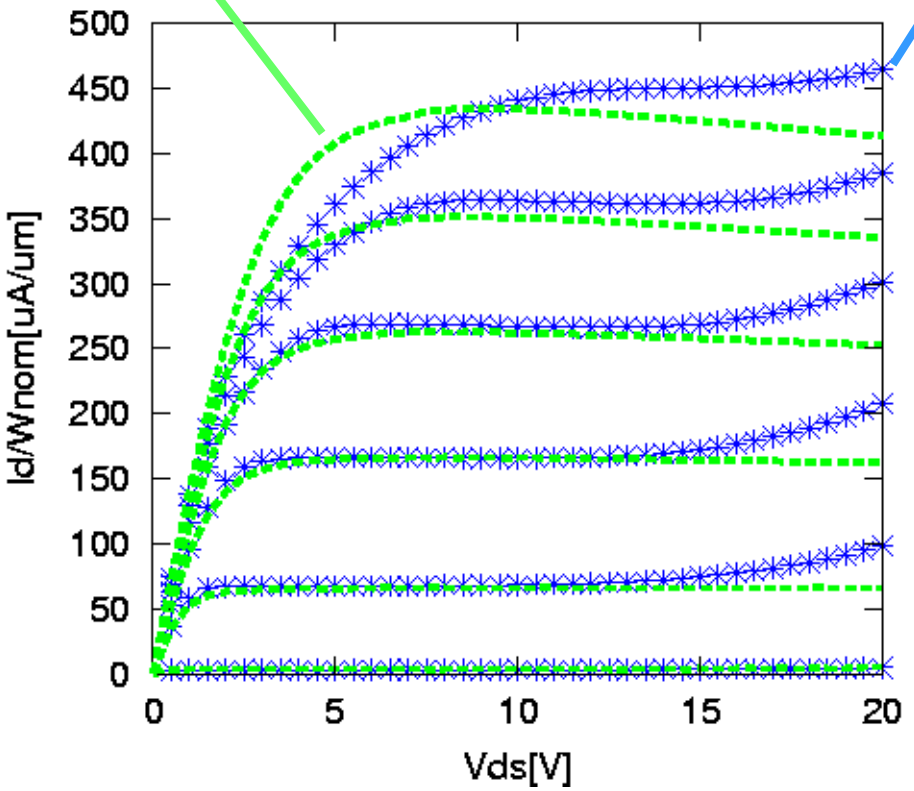

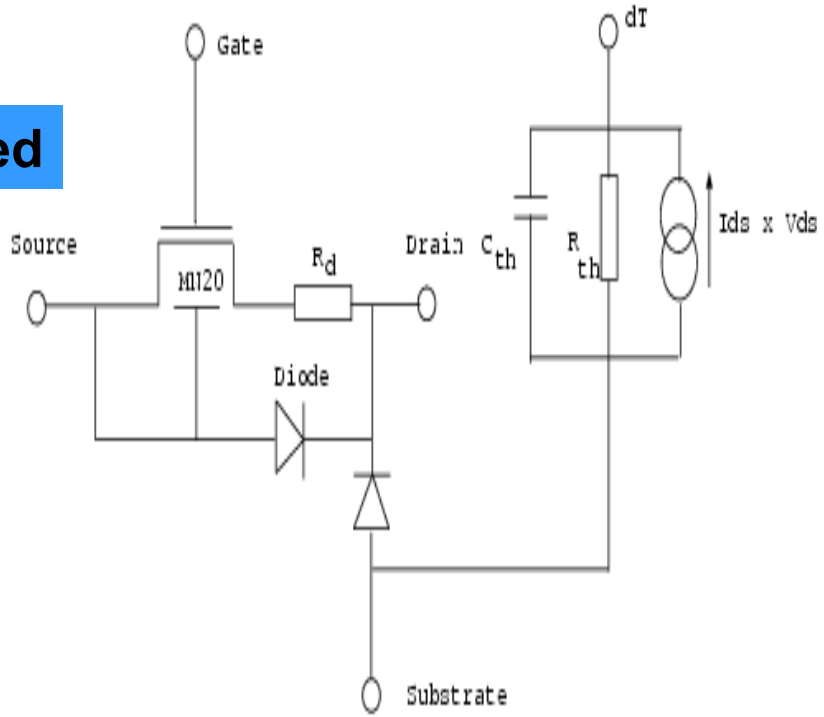

avalanche multiplication current
(history of problem)

MM2002

I-V characteristics
Vgs=1/…/6 V

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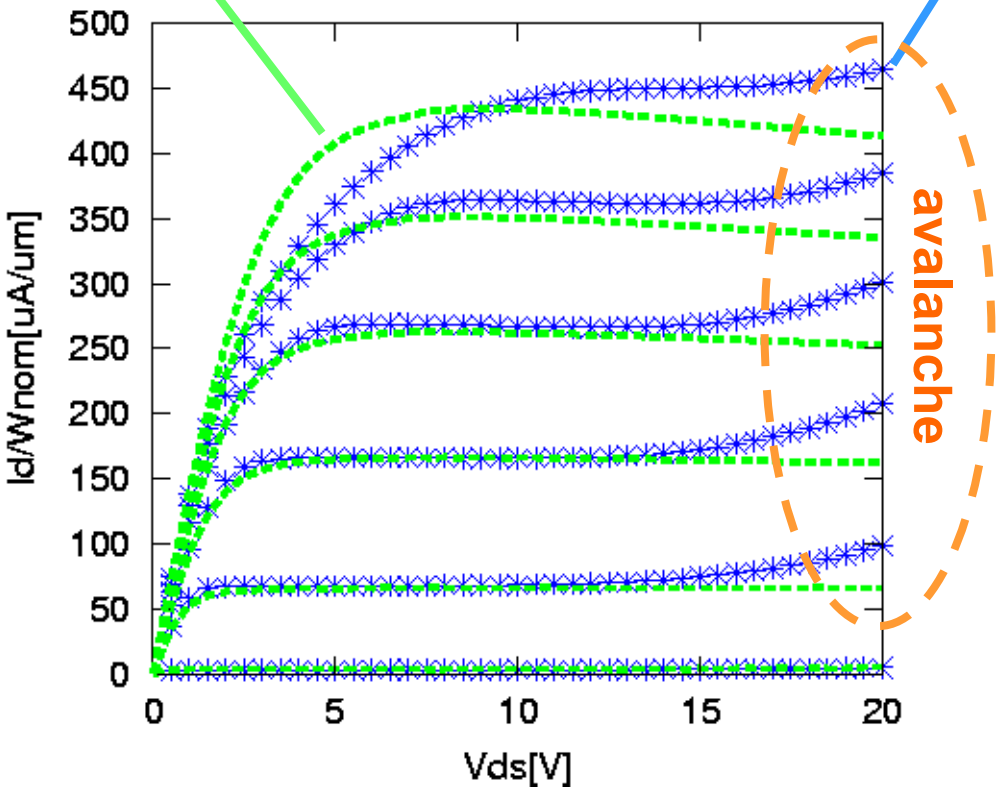
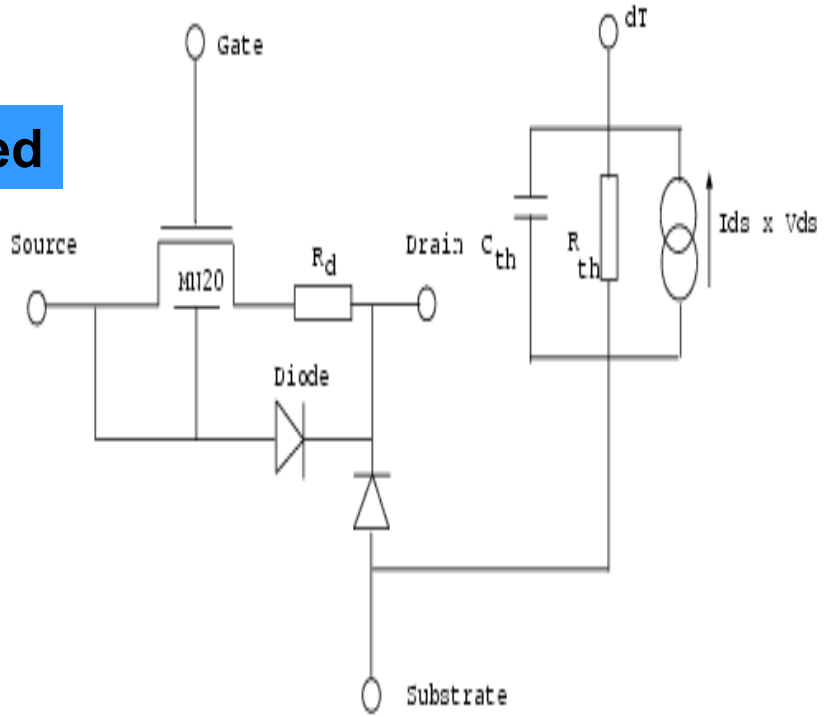
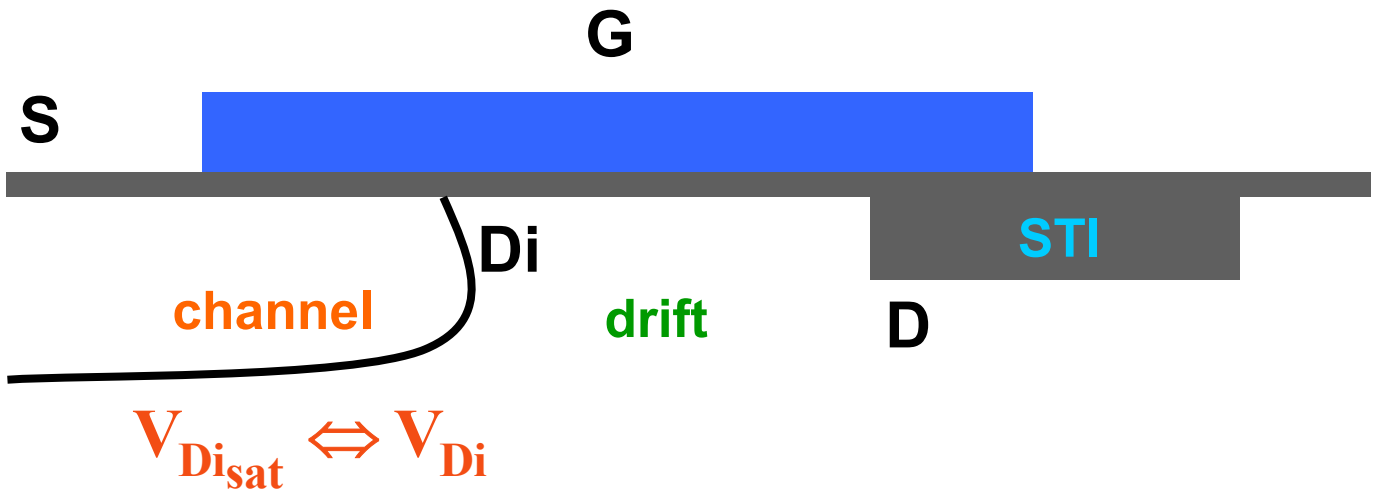




avalanche current modelling is poor in MOS Model 2002

avalanche current formulation



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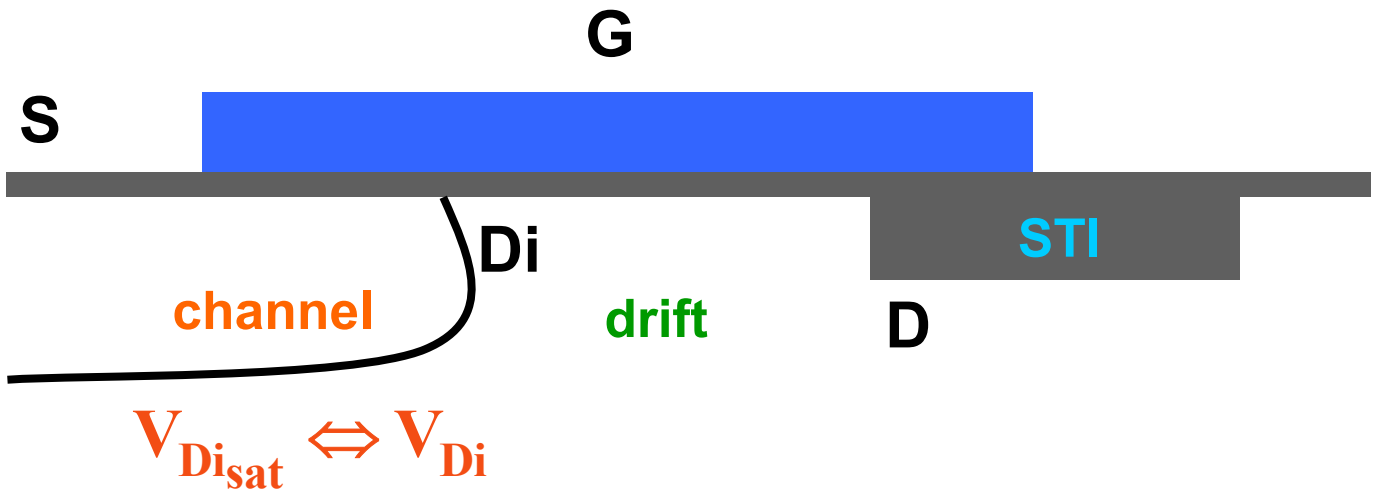
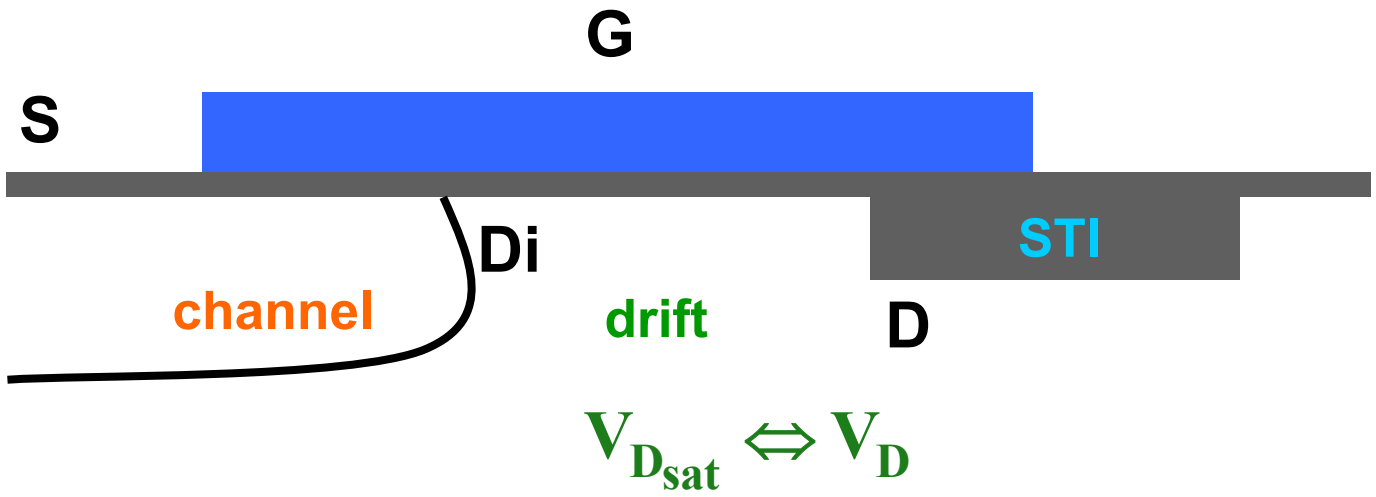


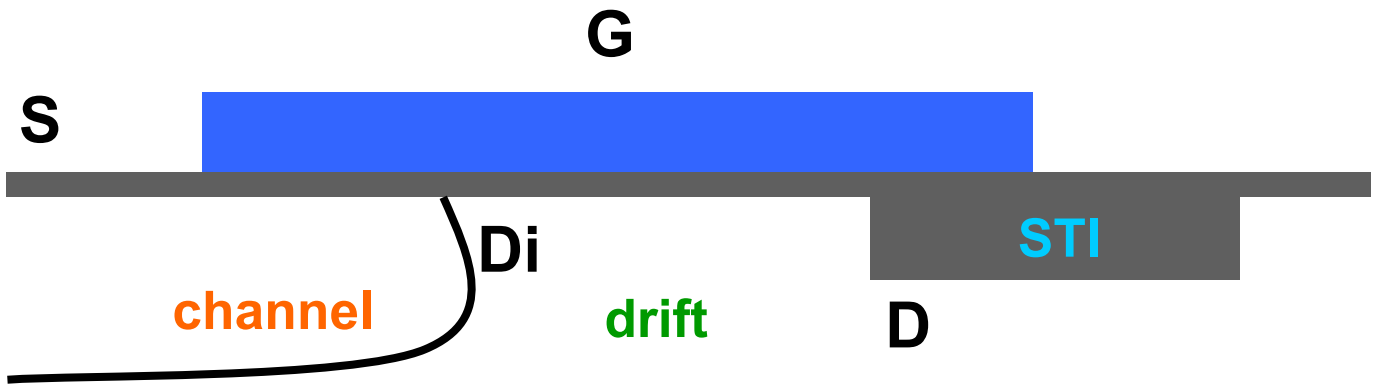
$$I_{avl_{CH}} = a_{1CH} \left| I_{DS} \right| \exp \left[- \frac{a_{2CH}}{\left| V_{Di} \right| - a_{3CH} V_{Di\ sat}} \right]$$

channel region contribution

avalanche current formulation



avalanche current formulation

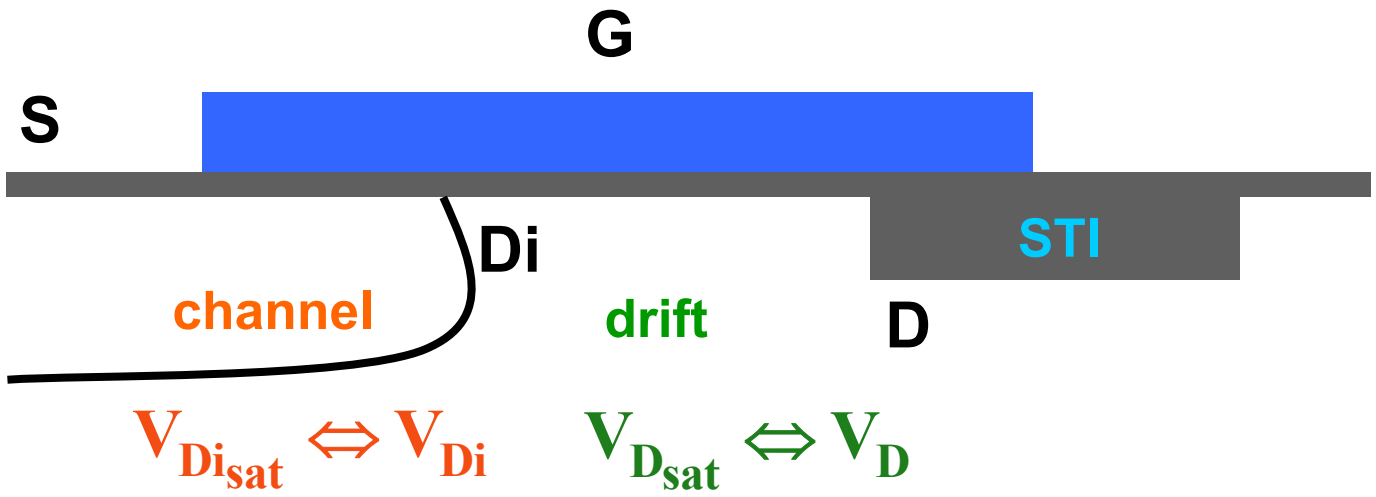


$$V_{D_{sat}} \Leftrightarrow V_D$$

$$I_{avl_{DR}} = a_{1DR} \left| I_{DS} \right| \exp \left[- \frac{a_{2DR}}{\left| V_D \right| - a_{3DR} V_{D_{sat}}} \right]$$

drift region contribution

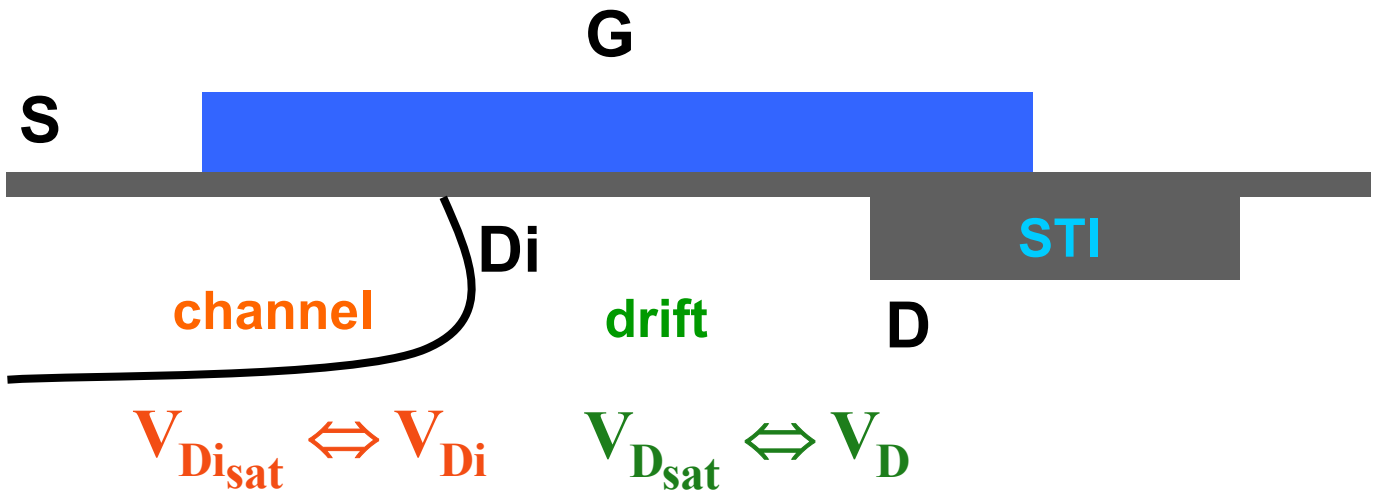
avalanche current formulation



$$I_{avl} = I_{avl_{CH}}$$

old avalanche model

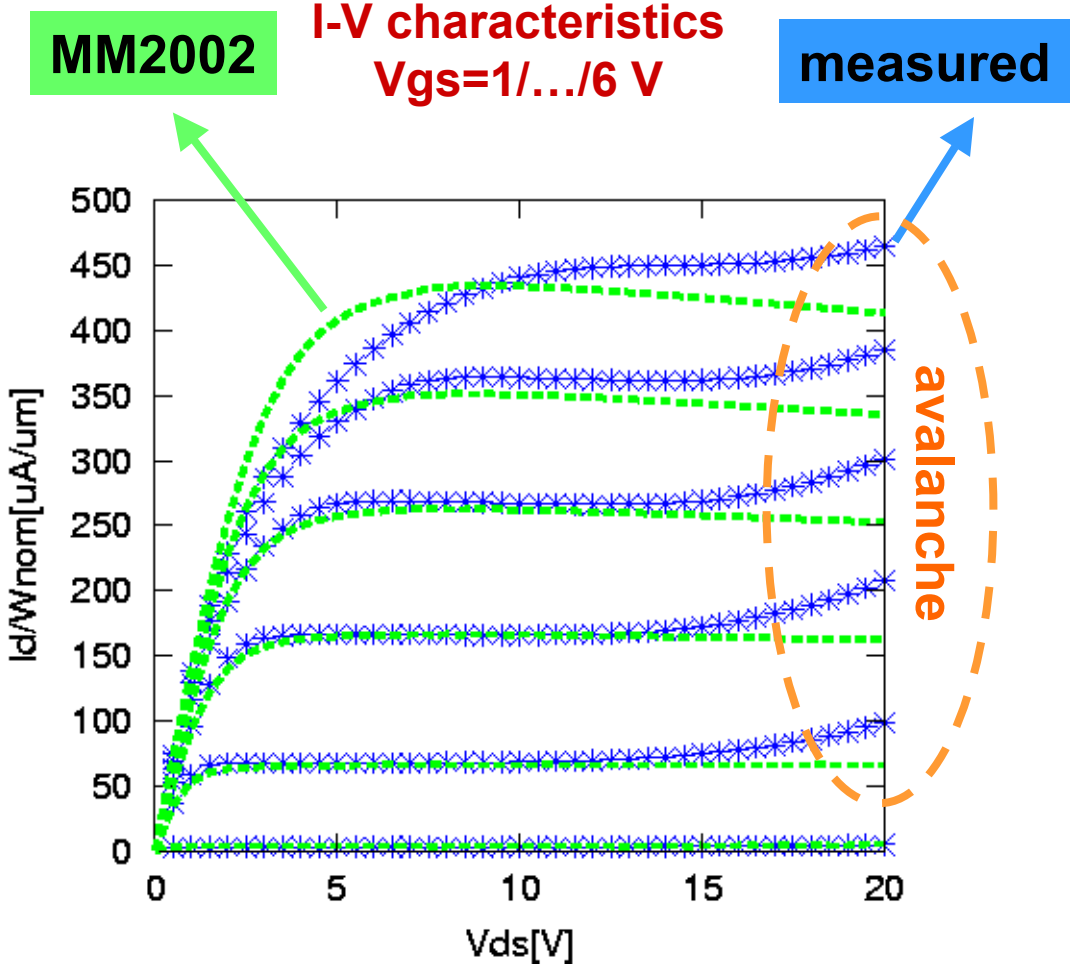
avalanche current formulation



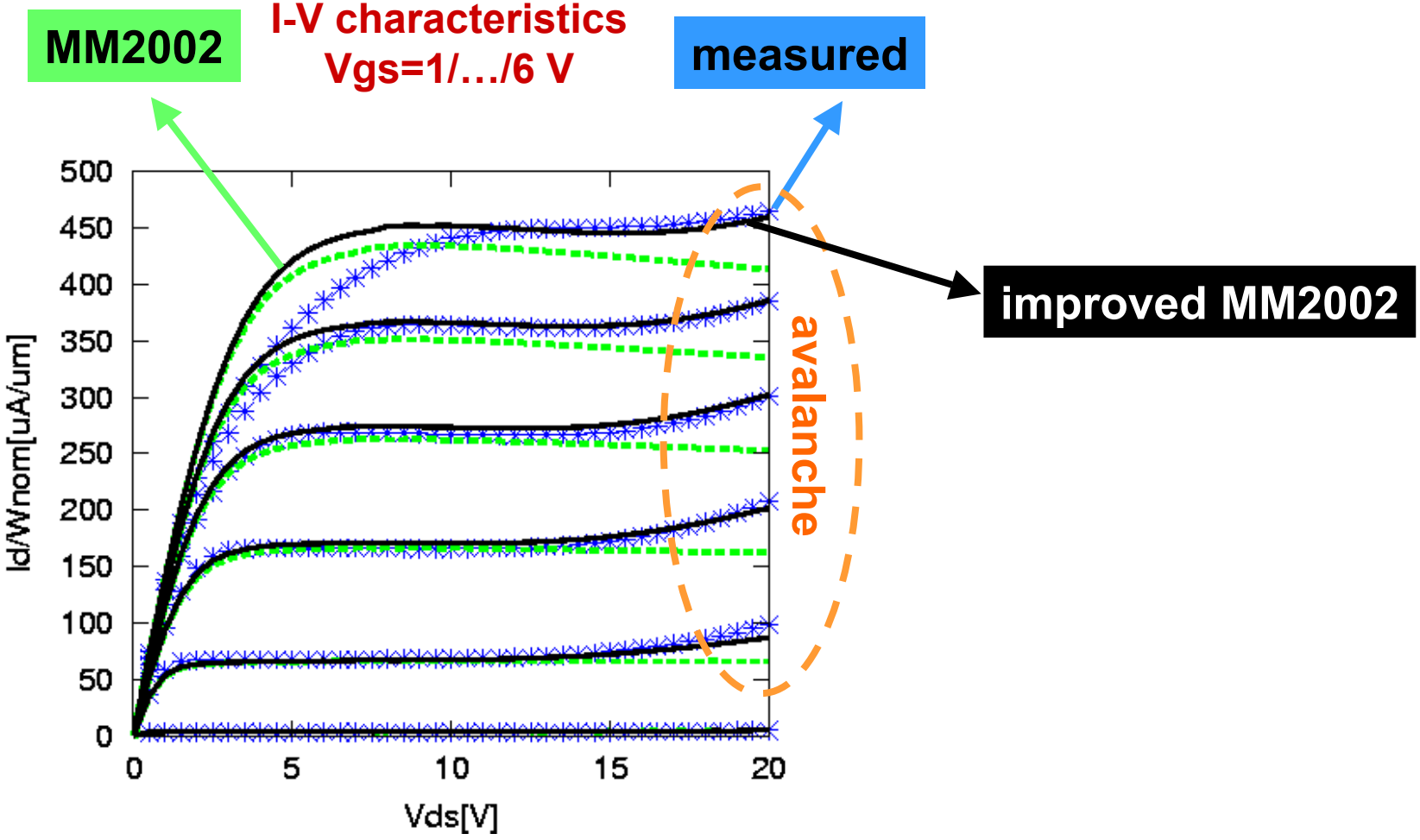
$$I_{avl} = I_{avl_{CH}} + I_{avl_{DR}}$$

new avalanche model

avalanche multiplication current



avalanche multiplication current
(comparing old & new models)



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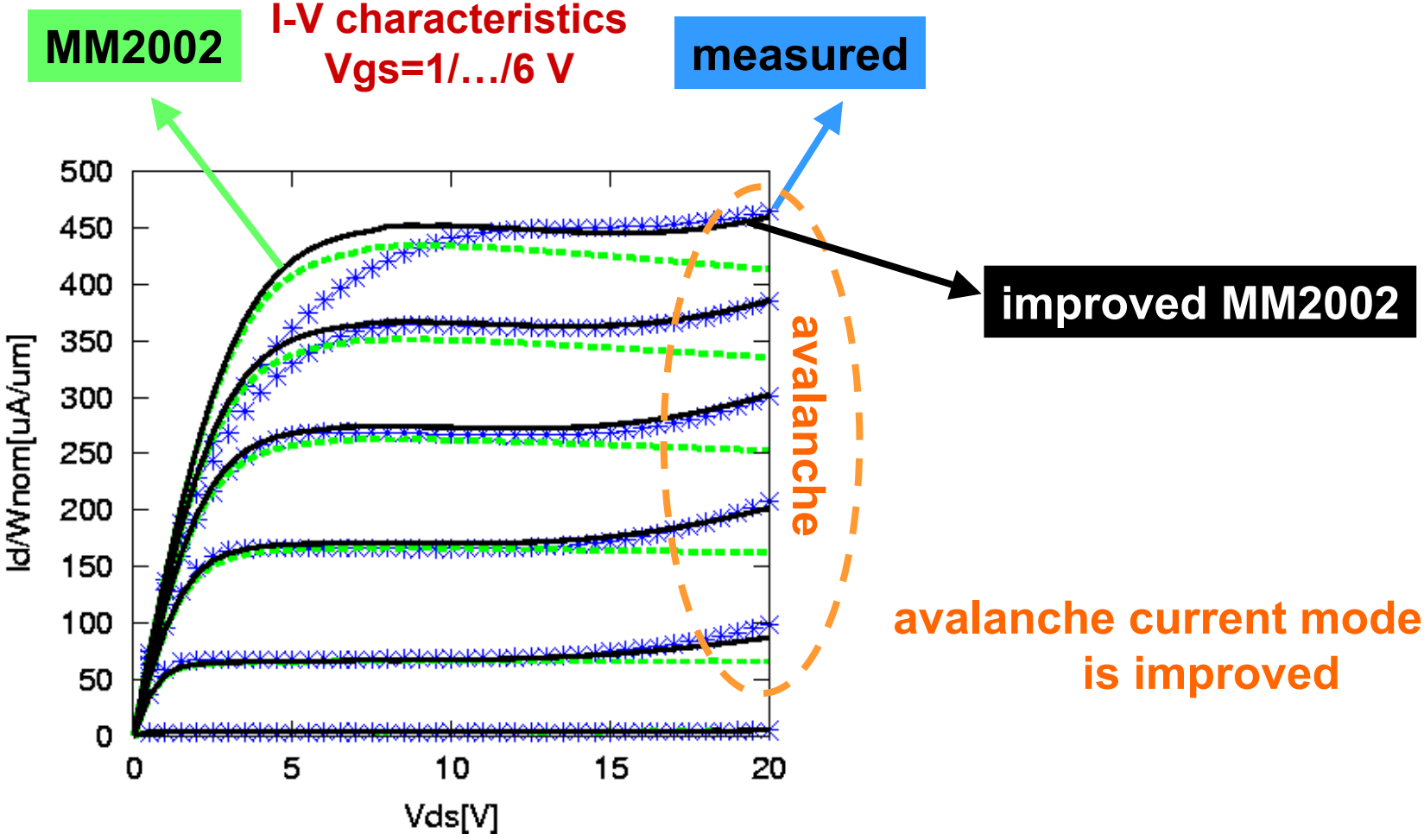

avalanche current modelling is improved

MOS Model 20, level 2002

update of avalanche model

electrical parameters:

- channel region parameters

- **A1CH:** Factor of channel avalanche current at reference temperature
- **STA1CH:** Temperature scaling coefficient for A1CH
- **A2CH:** Exponent of weak avalanche current related to channel region
- **A3CH:** Factor of internal drain-source voltage above which avalanche occurs

- drift region parameters

- **A1DR:** Factor of drift avalanche current at reference temperature
- **STA1DR:** Temperature scaling coefficient for A1DR
- **A2DR:** Exponent of weak avalanche current related to drift region
- **A3DR:** Factor of drain-source voltage above which avalanche occurs

MOS Model 20, level 2002

update of avalanche model

geometrical parameters:

- channel region parameters

- **A1CHR:** Factor of channel avalanche current of an infinitely wide transistor, at reference temperature
- **SWA1CH:** Width scaling coefficient for A1CH
- **STA1CH:** Temperature scaling coefficient for A1CH
- **A2CH:** Exponent of weak avalanche current related to channel region
- **A3CH:** Factor of internal drain-source voltage above which avalanche occurs

MOS Model 20, level 2002

update of avalanche model

geometrical parameters:

- drift region parameters

- **A1DRR:** Factor of drift avalanche current of an infinitely wide transistor, at reference temperature
- **SWA1DR:** Width scaling coefficient for A1DR
- **STA1DR:** Temperature scaling coefficient for A1DR
- **A2DR:** Exponent of weak avalanche current related to drift region
- **A3DR:** Factor of drain-source voltage above which avalanche occurs

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update of C-code in SimKit

MOS Model 20: 2002.1, to be released in Simkit 2.4 (October 2006), will include:

- **new avalanche current model**
- **corrections based on the comments of Geoffrey Coram (Analog Devices):**

  - correct clip-low value for W and WD, to be set at 1nm
  - in the iterative procedure of calculating the internal drain, one gets

$$I_{ch}=0 \text{ for } V_{dis}=0$$

$$I_{dr}=0 \text{ for } V_{dis}=V_{ds}$$

thus no need to calculate I_{ch} and I_{dr}

… and fixes to various smaller issues/inconsistencies (having no impact on characterization)

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update of model documentation

MM2002 model documentation, expected to be released in October 2006, will include:

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  - **correct clip-low value for W and WD, to be set at 1nm**
  - **correcting some formulas in the iterative procedure**
  - **correct formula for the drift charge**

… and some smaller issues

update of model documentation

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  - **correct formula for the drift charge**

… and some smaller issues

documentation and source code available on website:
http://www.nxp.com/Philips_Models/high_voltage/model20/index.html

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future plans

- self-heating in MOS Model 2002 planned for SimKit 2.5, to be released in March 2007
- improving quasi-saturation behaviour