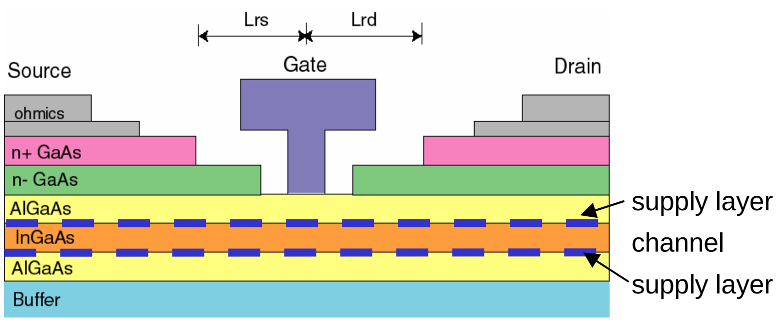
The Impact of Drain Recess Length on the RF Power Performance of GaAs PHEMTs

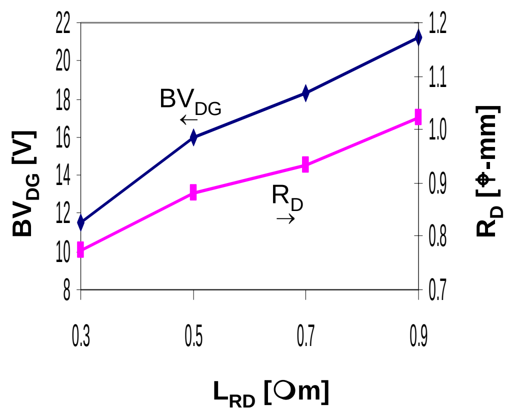
Melinda Wong[1], Jesus del Alamo[1], Akira Inoue[2], Takayuki Hisaka[2], and Kazuo Hayashi[2]

[1]Massachusetts Institute of Technology, Microsystems Technology Laboratory, Cambridge, MA (USA)
[2]Mitsubishi Electric, Itami, Hyogo, Japan



- GaAs Pseudomorphic High Electron Mobility Transistors (PHEMTs) are widely used in RF power applications

- Want to increase output power by increasing L_{RD}



Good for power :

- $L_{RD}\uparrow \Rightarrow BV_{DG}\uparrow \Rightarrow V_{DS}\uparrow \Rightarrow P_{OUT}\uparrow$

Bad for power :

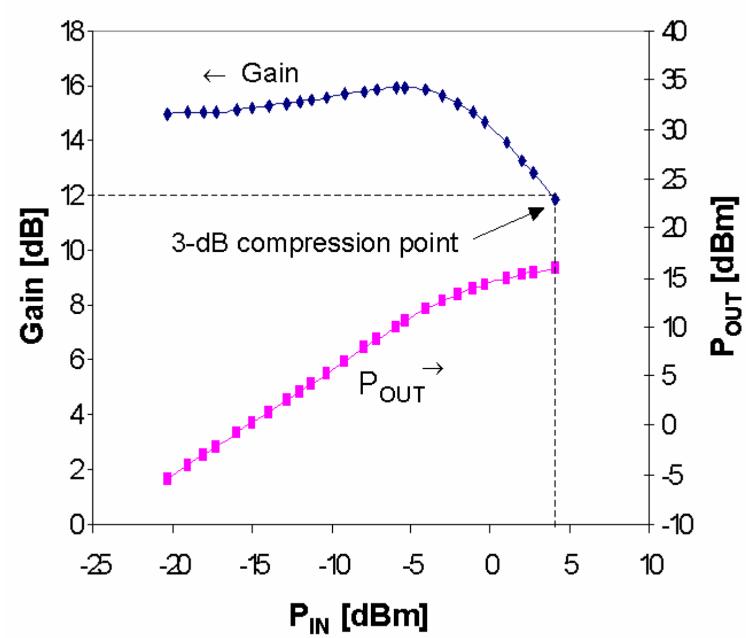
- $L_{RD}\uparrow \Rightarrow R_D\uparrow \Rightarrow P_{OUT}\downarrow$

Published results: $L_{RD}\uparrow \Rightarrow P_{OUT}\downarrow$

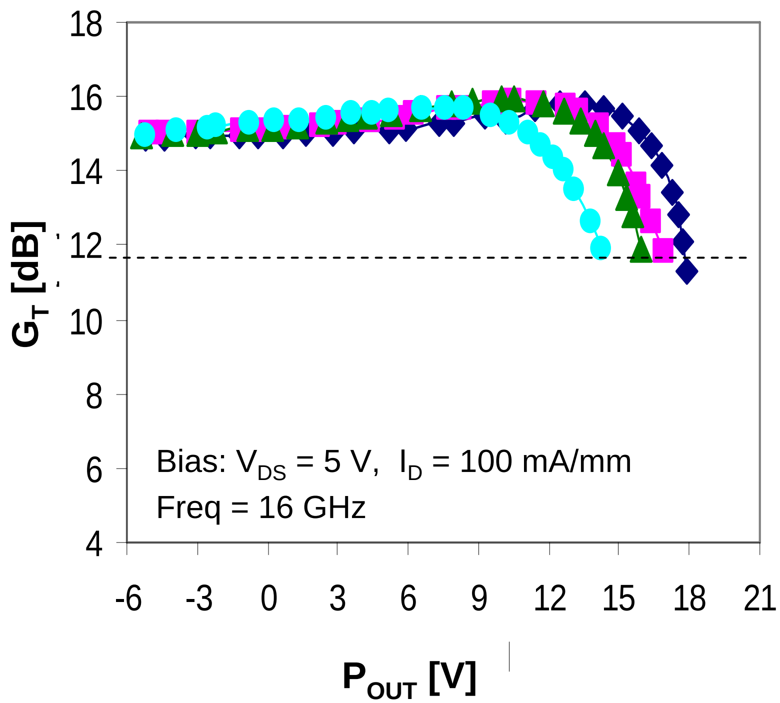
RF Measurement Methodology

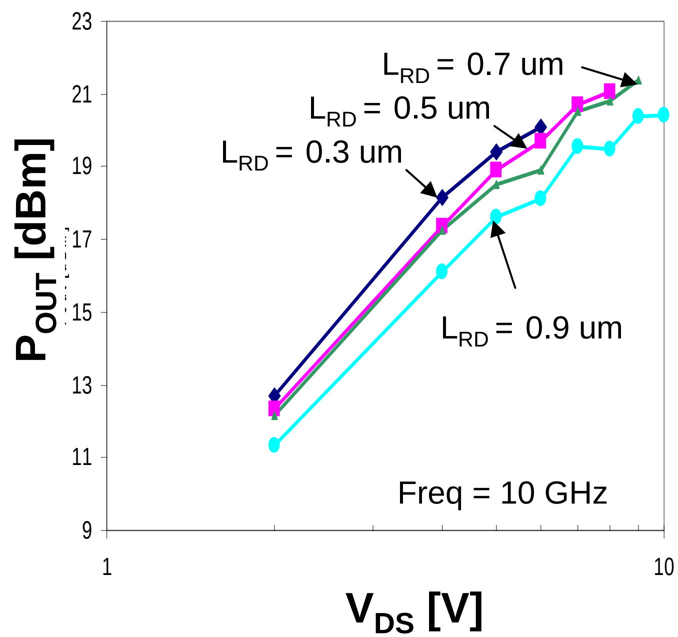
- Study 4x40 devices (L_G = 0.25 um) with different L_{RD}
- Carry out load pull measurements
  - Bias at I_D = 100 mA/mm and different V_{DS}
  - Optimize for P_{OUT}
  - G_T = 15 dB
  - f = 10, 16 GHz

L_{RD} [um]	BV_{DG} [V]	f_{Tpeak} [GHz]
0.3	12	65.0
0.5	16	64.0
0.7	18	61.8
0.9	21	60.2



Large Signal Performance vs. L_{RD}





- **Experimental:**

  L_{RD} ↑ $\Rightarrow$ P_{OUT} ↓

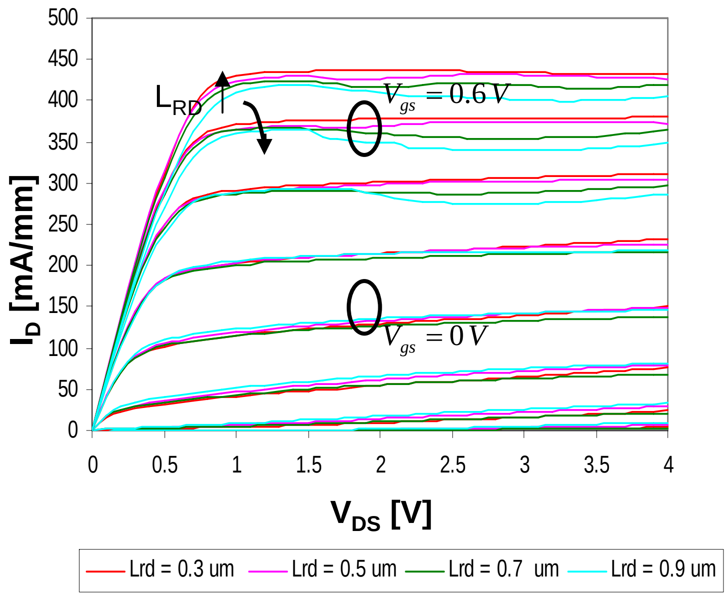
- P_{OUT} ✪ V_{DS}^2

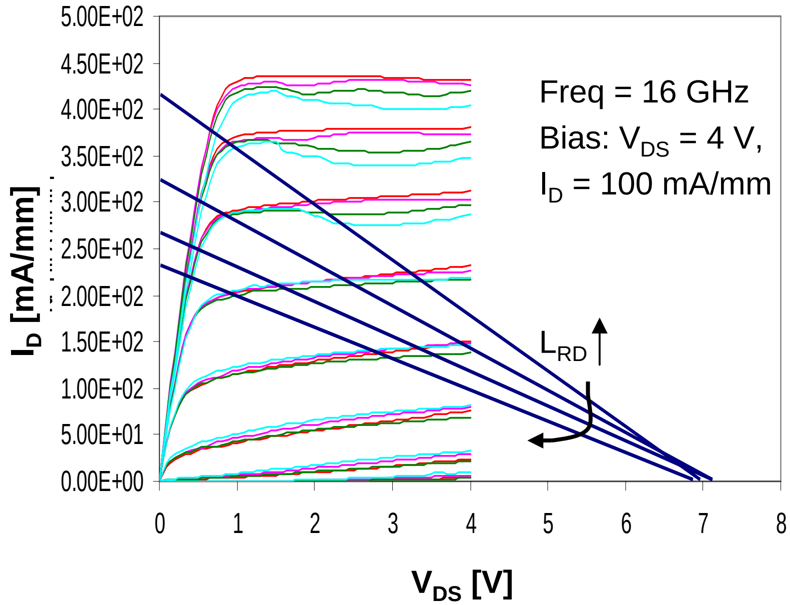
- Maximum allowable V_{DS}:

  $$V_{DS} < \frac{1}{2}\left(V_{KNEE} + BV_{DG}\right)$$

- L_{RD} = 0.7 um device delivers greatest power

Load line analysis





- L_{RD} ↑ ⇒ $V_{DS,SAT}$ ↑, I_{MAX} ↓ ⇒ P_{OUT} is reduced

- Load lines become *shallower* as L_{RD} increases
  - Not advantageous from a power standpoint
  - Due to 15 dB restriction

$$|A_V| = g_m \cdot R_L$$

L_{RD} ↑ ⇒ g_m ↓ ⇒ R_L ↑ to keep G_T constant

Conclusions

- An optimum L_{RD} :
  - Must be chosen to achieve the highest P_{OUT} possible
  - Is reduced as operating frequency increases

- As L_{RD} $\uparrow$:
  - Earlier and softer compression
  - Load lines become increasingly shallow
  - I_{MAX} $\downarrow$
  - g_m $\downarrow$
  - $f_T \downarrow \Longrightarrow \tau_{drain} \uparrow$ due to the extension of the depletion region (see poster for additional details)