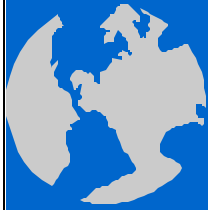


MTT 2001
Vdmos vs. LDMOS
How to Choose



Polyfet Rf Devices
S. K. Leong
Tuesday, May 22, 2001



Vdmos vs Ldmos

- History
 - Technology - Process Structure Differences.
 - DC Characteristics
 - RF Characteristics
 - Gain, Stability, Ruggedness
 - Applications
 - HF, VHF, Low UHF, High UHF, PCS
- 

Tale of Contents

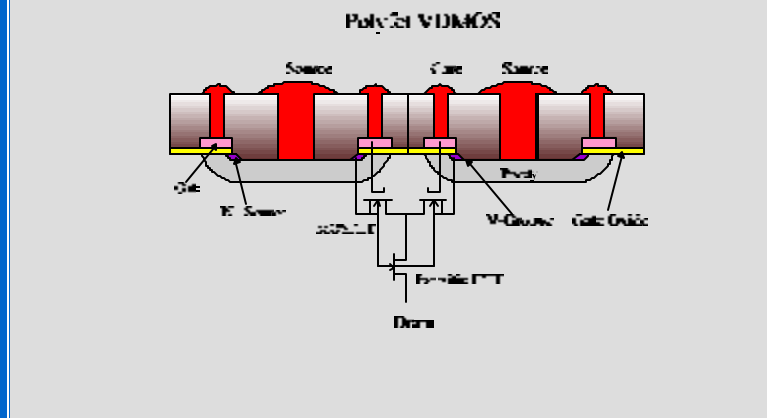
HISTORY OF RF MOSFET

- 1970s - Siliconix Vgroove VHF
- early 1970s - Acrain Isofets, PHI,
- 1978 - Motorola, Philips
- 1985 - Polyfet Gold Metal 1 Ghz Vdmos.
- late 1980s - Ldmos Hitachi, Motorola
- 1990s - Ldmos Polyfet, Ericsson, Philips, others

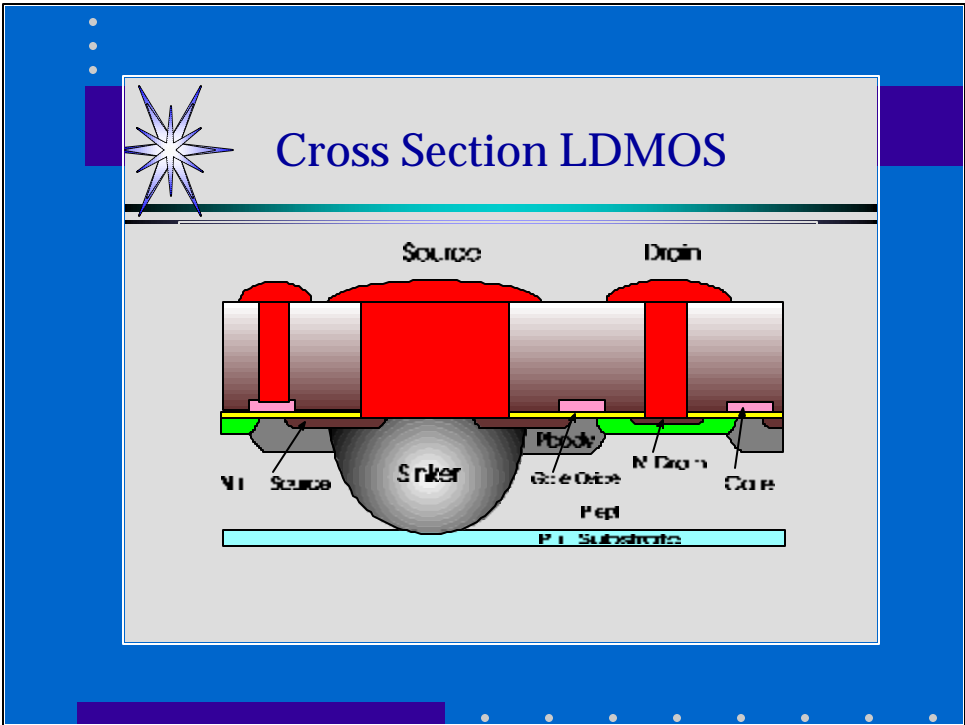
Polyfet - first in the world to introduce top metal gold for Power Rf Mosfet transistor at 1 Ghz operation.



Cross Section VDMOS



Vertical DMOS - Current flows in vertical direction from drain to source.
Bottom side of die is drain - High Potential..



Lateral DMOS - Current flows laterally from drain to source. Bottom side of die is Source - Ground Potential.

Key Differences

Lateral DMOS

- ◆ Bottom Side Source
- ◆ No source bondwire
- ◆ Higher gain
- ◆ Lower Crss
- ◆ Higher Power given equal die size.
- ◆ Higher Efficiency
- ◆ BEO not required
- ◆ Improve θ_{jc}

Vertical DMOS

- Source bond wire reducing gain
- Higher Crss
- BEO isolation
- Bottom Side Drain

Advantages to Ldmos. Panacea - replace all other technologies?

DC Characteristics

- Similar between Vdmos and Ldmos in Gm and IV characteristics.
- Crss is lower in Ldmos
- Spice model represented by MOSFET with series JFET in both technologies.

Similarities in both technologies.

Some RF Comparison

Same Silicon Area comparison

@ 1000 Mhz

- LP801 15W 12 dB 60% AP Single Ended LDMOS
- F2012 10W 10 dB 35% AP Single Ended VDMOS

@ 500 Mhz

- LP801 20W 13 dB 70% AP Single Ended LDMOS
- F2012 15W 12 dB 45% AP Single Ended VDMOS

Superior Gain, Power Output and efficiency for Ldmos devices vs. Vdmos devices at high frequencies.

Gain and power improvements decreases with decreasing frequency.

STABILITY ISSUES

- In band and Out of Band instability.
- Stability as a function of input signal.
- Stability - Gain trade off.
- Input stabilization.
- MTT 1997 - Stabilizing Mosfet Amplifiers

Vdmos instability is at lower frequencies and can be overcome with resistive loading of the gate circuit (1).

The fact that the forward gain of the Ldmos has increased (by processing) more than the reverse gain has decreased contributes to its instability.

In the case of the Ldmos the areas of instability extend into the operating bandwidth and beyond. If one observes the small signal S parameters it is very apparent the region's instability extend well into the Smith Chart. This cause a design challenge for RF professionals. Not only must one match into and out of the device with the proper impedances, they must also avoid crossing areas of instability and a multitude of frequencies above and below the operating frequency. Due to the nature of matching structure, it is almost inevitable that one will cross into a region of instability. As mentioned earlier, lower out of band instability can be controlled without major deterioration of performance in the operating band. Instability in the operating band and above the operating band is much more of a design challenge because there is a compromise within the band performance.

Since the F_t of the device at any instant in time varies with the drain voltage and drain current, the regions of instability change with the applied signal. The result of this effect, usually cause device failure with no apparent reason.

It must be remembered any device should be stabilized for unconditional stability both at small signal level as well as at high power. - Easier said than done.

KEY ADVANTAGES

VDMOS

- Higher Input Impedance
- More Rugged
- More Stable
- High Power 600W

LDMOS

- Low C_{rss} - Better output input isolation.
- High Gain.
- High Efficiency @ high Freq.
- High Frequency - > 2 Ghz

Higher input impedance on the Vdmos allows easier broadband matching.

Ldmos low input impedance resulting in high Q input match. Suitable for cellular PCS and IMT2000 band since the bandwidths are relatively narrow - 5%.

LDMOS - the only alternative Mosfet above 500 Mhz for significant power.

Stability

Even though C_{rss} is lower, the gain is so much higher, the result is less stability in Ldmos. Can extend into and above operating band.

Broadband

Vdmos with higher input impedance and stability over a broader frequency range make it more suitable for broadbanding over several octaves

APPLICATIONS

VDMOS

Broad Band
Raw Power
CW - FM / AM
More rugged
More stable
Lower Frequencies

LDMOS

- Narrow Band
- High Frequency
- PCS - high linearity
- High Gain
- High Efficiency
- Operate Backed Off
- High gain driver stage

VDMOS

Less chance for in band oscillation and lower input Q - better match.
Best for broadband and <500 Mhz.

LDMOS

Better choice in narrow band and high frequency applications.

Since adequate performance can be obtained at frequencies below 500 Mhz with Vdmos devices, there is not adequate justification to use the the higher frequency of the Ldmos. The desire for higher power gain may drive a designer to use a high frequency part in a low frequency application, but a word of caution, for every decibel of additional forward gain, there is a reduction in circuit stability. Since absolute stability cannot be easily measured, the benchmark of performance is usually gain with the stability issues only becoming evident when the devices are failing for no apparent reason.

Recommendations

- 1 - 30 Mhz HF Band - VDMOS
- 30 - 500 Mhz VDMOS - LDMOS
- 500 - 1500 Mhz LDMOS - VDMOS
- > 1500 Mhz LDMOS

Polyfet has spent years developing both Vdmos and Ldmos devices. If we separate operating bands into HF, VHF and UHF, we can generalize on the type of technology which offers the best compromise between performance and reliability.