High Speed Transistors. Summary

High Speed Electronic Circuit technologies

Silicon Bipolar

GaAs MESFETs

III-V HFETs

GaAs-based HBTs

Si-Ge based HBTs

Silicon Bipolar

- ft over 300 GHz
- Low 1/f noise
- Low phase noise
- Low surface recombination velocity - high gain
- pnp transistors available for active loads
- - lack of semi-insulating substrate - high parasitics

GaAs MESFETs

Mature technology

Usually fmax >> fT

Issues:

- backgating
- gate leakage
- threshold voltage variations

fT's for GaAs MESFETs

Manufacturer	Gate length (micron)	FT (GHz)
Oki	0.2	65
Triquint	0.6	21
Vitesse	0.45	44
	0.15	50

HFETs

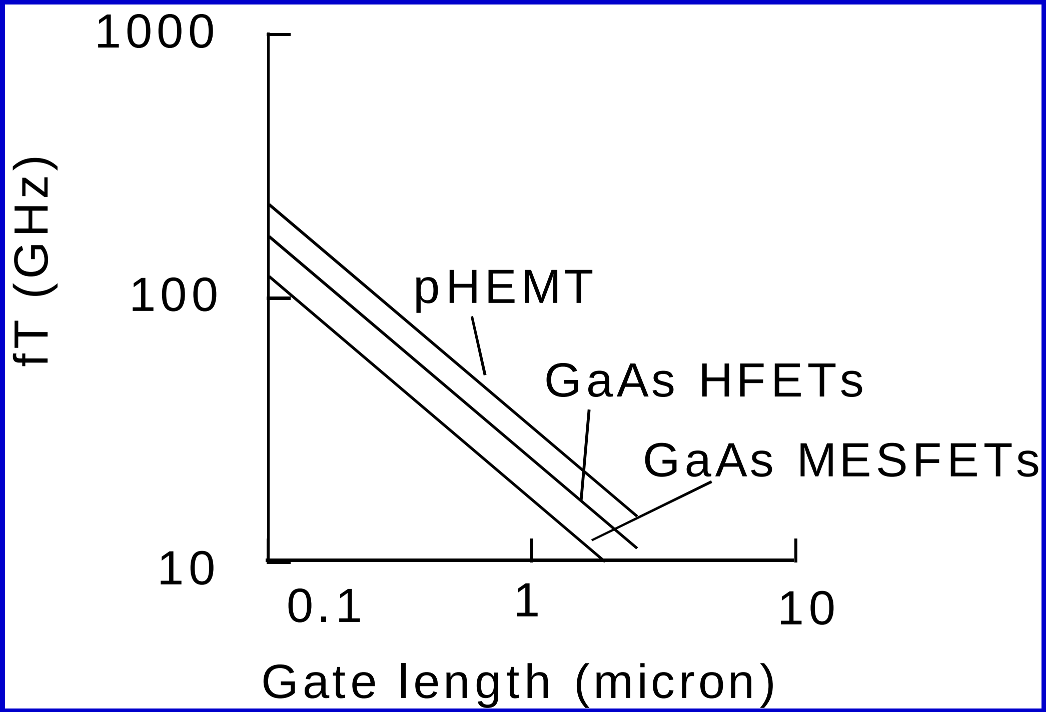
Higher fT and fmax

Low high frequency noise

Less backgating

- High 1/f noise

fT for III_V HFETs and MESFETs (approximate)



InGaAs based HBTs

Good threshold uniformity
High fT and fmax (up to 800 GHz with transferred substrate)
1/f noise better than for GaAs-based FETs, worse than for Si bipolar
high breakdown voltages
- maximum ft is reached at bias voltages different from operating voltages

InP based HBTs (InAlAs and GaInP emitter, InGaAs base)

Higher fT, fmax

Higher speed

Lower power onsumption

Low surface recombination velocity

1/f noise comparable to GaAs-based HBTs

- low collector-emitter breakdown voltage in single heterojunction HBTs (improved in double heterojunction HBTs)
- lack of large area substrates
- no commercially available parts

Si-Ge HBTs

20 to 30% speed improvement compared to Si BJTs

Compatible with Si fabrication technology

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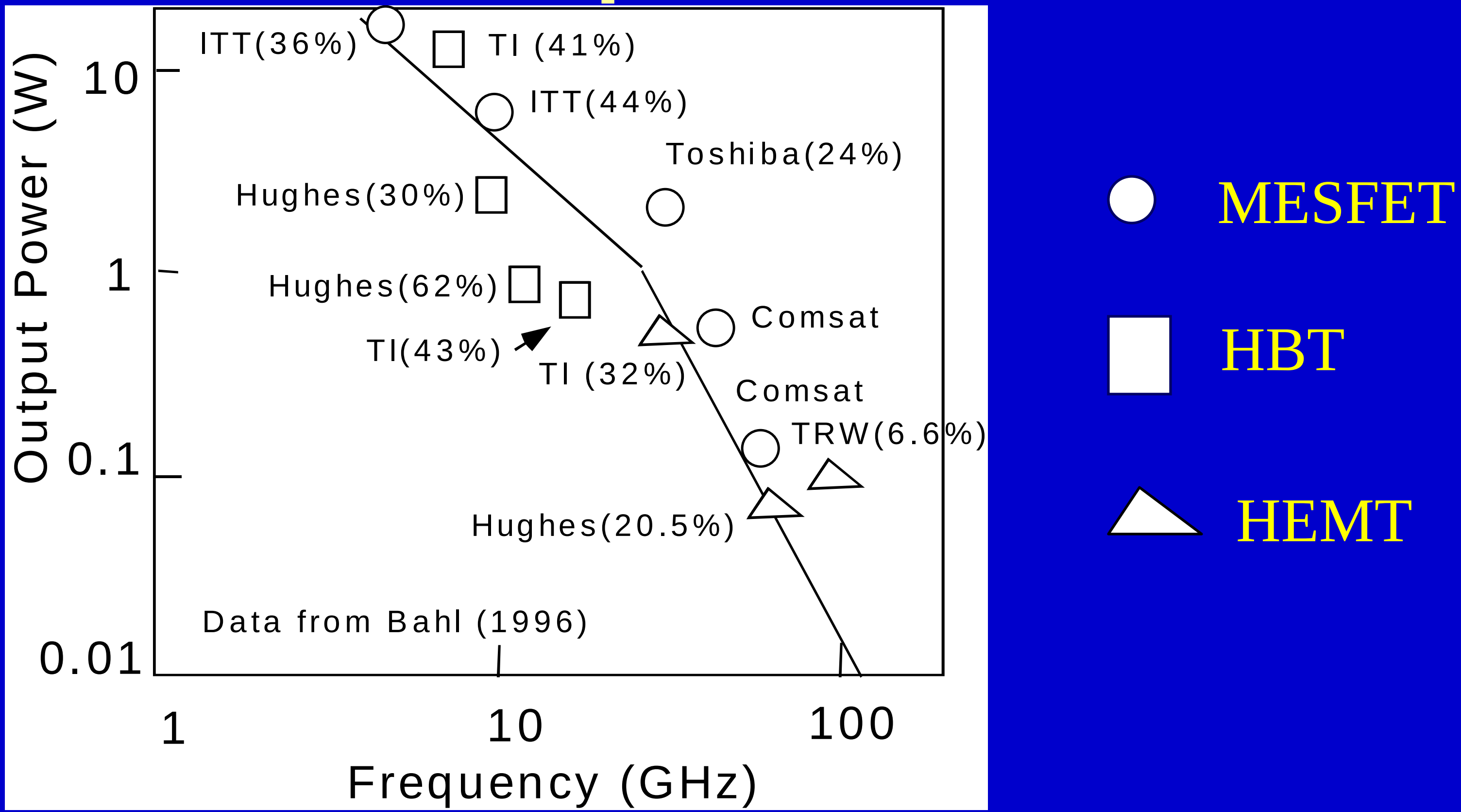
MESFET, HFET, HBT Comparison

	MESFET	HFET	HBT
1/f noise	High	High	Lower
RF performance	OK	Very good	Good
Breakdown	OK	Low	High
Power level	Up to 1 W/mm	Up to 1 W/mm	Up to 3 W/mm
Price		Least expensive	

Single Chip power MMIC amplifiers



(Data from I.J. Bahl, in Compound Semiconductor Electronics, The Age of maturity, WS, Inc., 1996, Ed. M. S. Shur, pp. 175-208)

Wide Band Predictions for GaN on SiC Power amplifiers (Blue Sky).
Based on materials properties

>Power **factor of 10 to 50 (based on Imax and Vbr)**
>instantaneous bandwidth **factor of 1.5 to 2 (based on v(E)**
>efficiency better **(based on a better impedance matching)**
>linearity **better (based on a more constant gm)**
>1/f noise **better (based on already measured noise)**
> high frequency noise **better (based on a low Rs)**
>size, weight **a factor of 10 smaller (based on performance)**
>cost **comparable to GaAs in a long run**