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High Power GaN HEMTs for WiMAX BTS

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- Introduction
- DC Characteristics and Load-Pull Results
- 3.5GHz 40W GaN HEMT
- 3.5GHz 200W GaN HEMT
- 3.5GHz 2-stage Amplifier
- Summary

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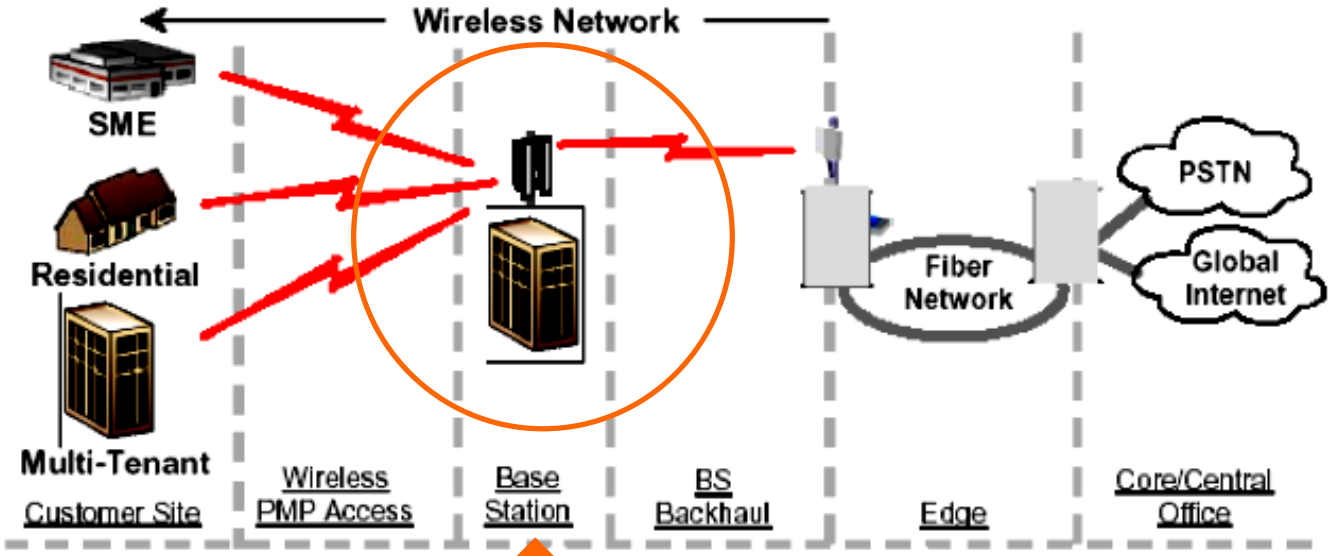
Requirement of WiMAX BTS Amplifier

- High Power, High Efficiency and High Gain
- High Frequency with Broad Band
  - 200MHz Band Width at 2.6GHz and 3.5GHz
- High Linearity
  - Low EVM Characteristics



Our Target:EVM<3.0% at Pave=10W(40dBm)
3.5GHz, PAR12dB OFDM Signal

Psat>52dBm

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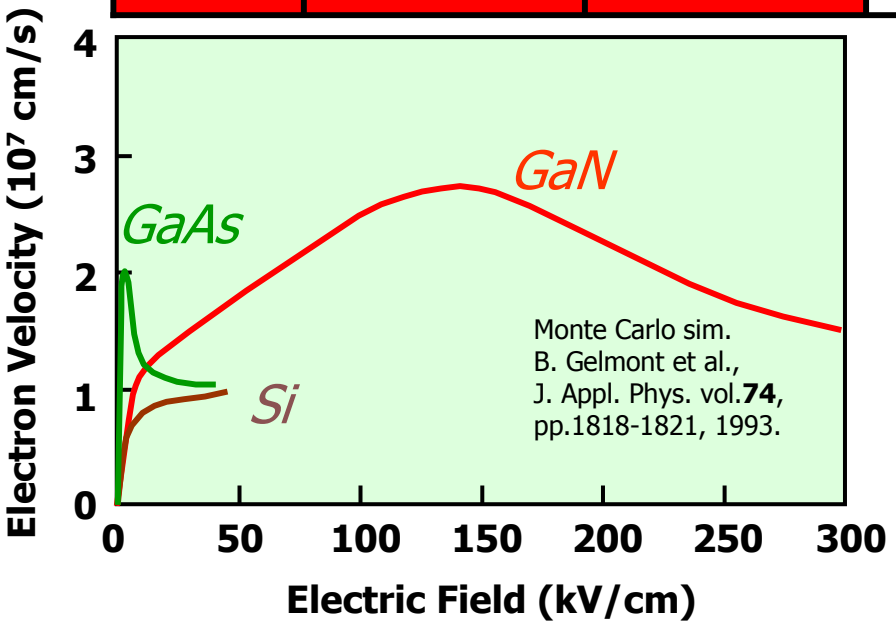
Material Property of GaN

Material	Bang Gap Energy (eV)	Critical Breakdown Field (MV/cm)	Thermal Conductance (W/cm/K)	Mobility ($cm^2/V/s$)	Saturated Velocity ($*10^7$ cm/s)
Si	1.1	0.3	1.5	1300	1.0
GaAs	1.4	0.4	0.5	6000	1.3
SiC	3.2	3.0	**4.9**	600	2.0
GaN	**3.4**	**3.0**	1.5	**1500**	**2.7**



Key features of GaN

- **High breakdown voltage**
- **Wide Band gap**
- **High thermal conductivity (SiC Substrate)**
- **High current density**
  - **High electron velocity**
  - **High sheet carrier density**

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Benchmark

Term	unit	Si-LDMOS	GaAs MESFET	SiC MESFET	GaN HEMT
Operation Voltage	V	28	28	50	50
Brakedown Voltage; Vgdo	V	75	75	(150)	350
Power Density	W/mm	0.7	0.7	4	5
Gain @2.17GHz	dB	15.5	14	12	18
Source Impedance@2.17GHz *1	Ω	0.3	0.3	?	3
Load Impedance @2.17GHz *1	Ω	1.5	2.9	?	45
Drain efficiency; ηd @2.17GHz*	%	50	50	50	65
Thermal Resistance *1	deg.C/W	1.2	1.6	?	(1.2)
Die size	---	Large	Large	Small	Small

Note ; *1 ; 10W Chip

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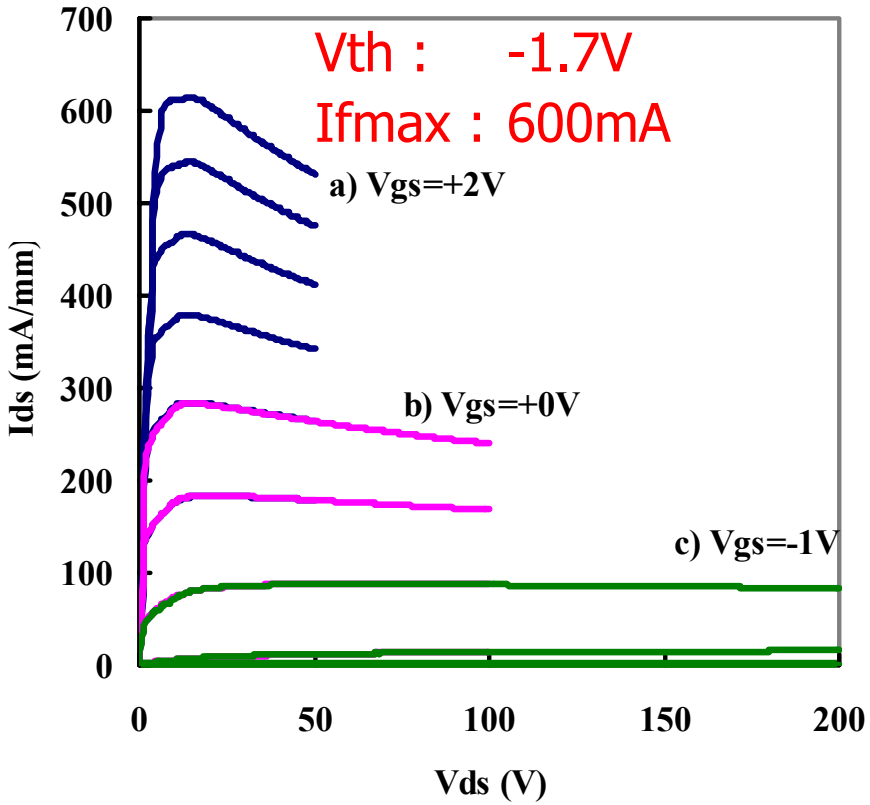
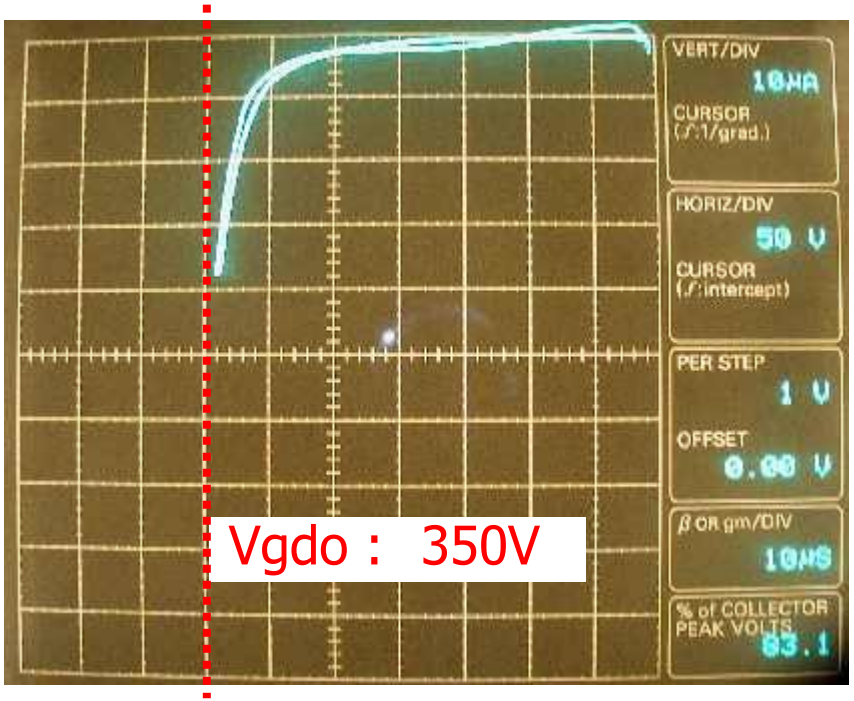
High Breakdown Characteristics

IV Characteristics



2 terminal Gate-Drain reverse



Good pinch-off characteristics up to 200V

Enough high fT of 14GHz to be operated at 3.5GHz

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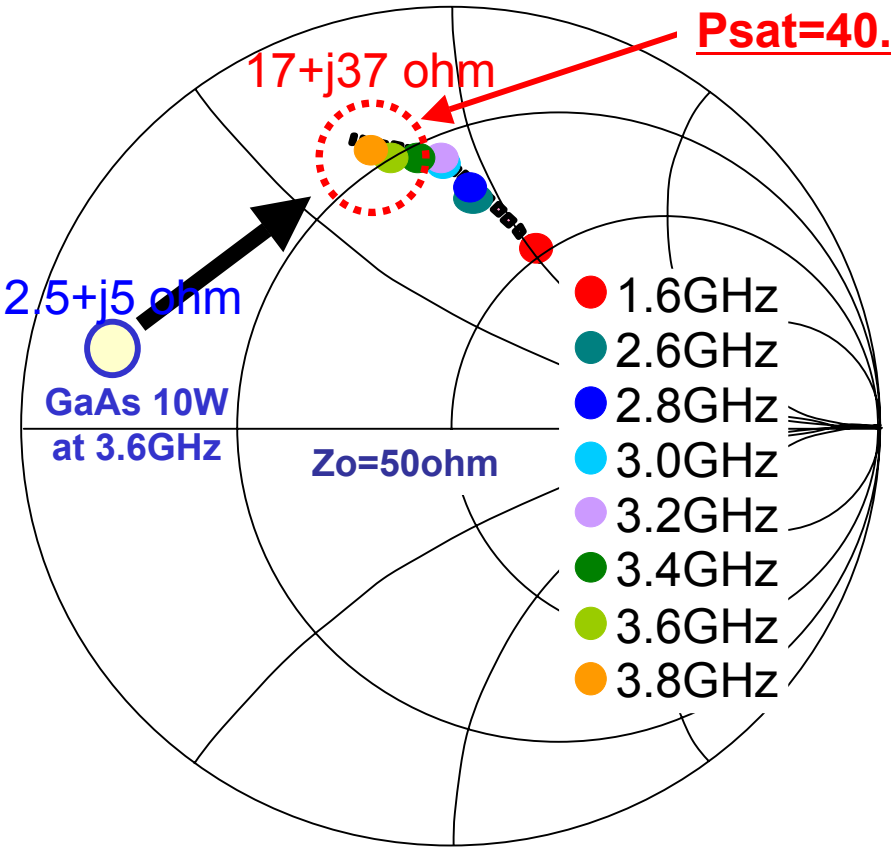
Loadpull Measurement Results

GaN HEMT Unit-cell; Wg=2.25mm, Vds=50V



Higher Output Load Impedance

- Broad Band Characteristics
- Simple Matching Circuit

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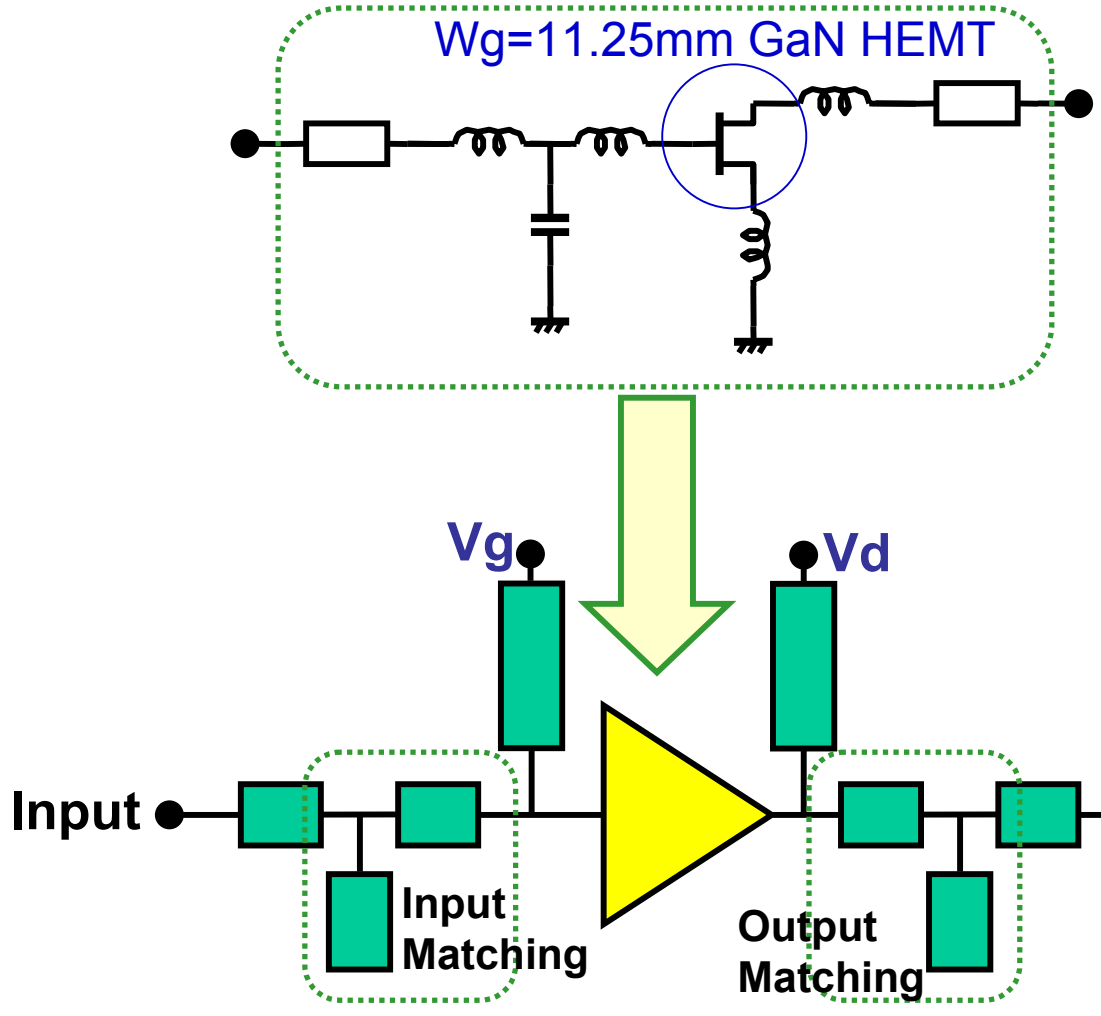
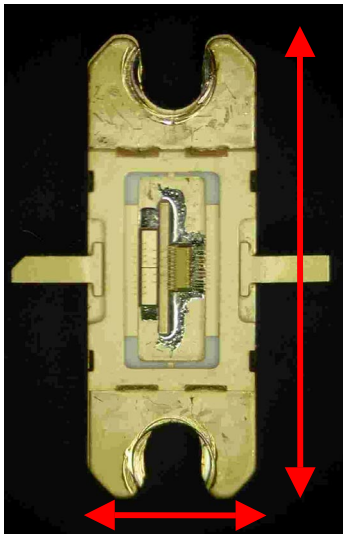
40W Device Design





Simple Matching Circuit with Small Package

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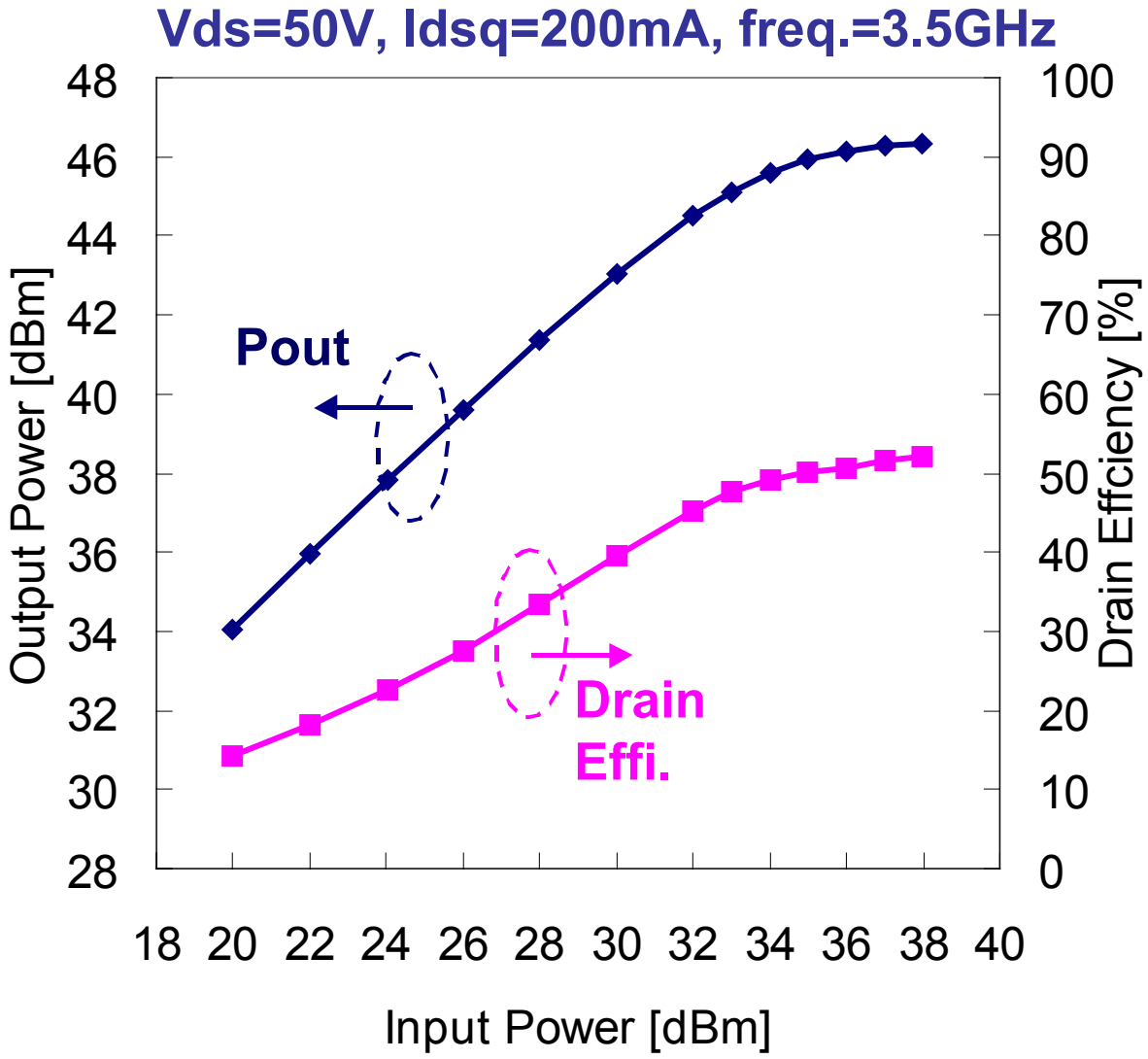
40W Device Pin-Pout and Efficiency



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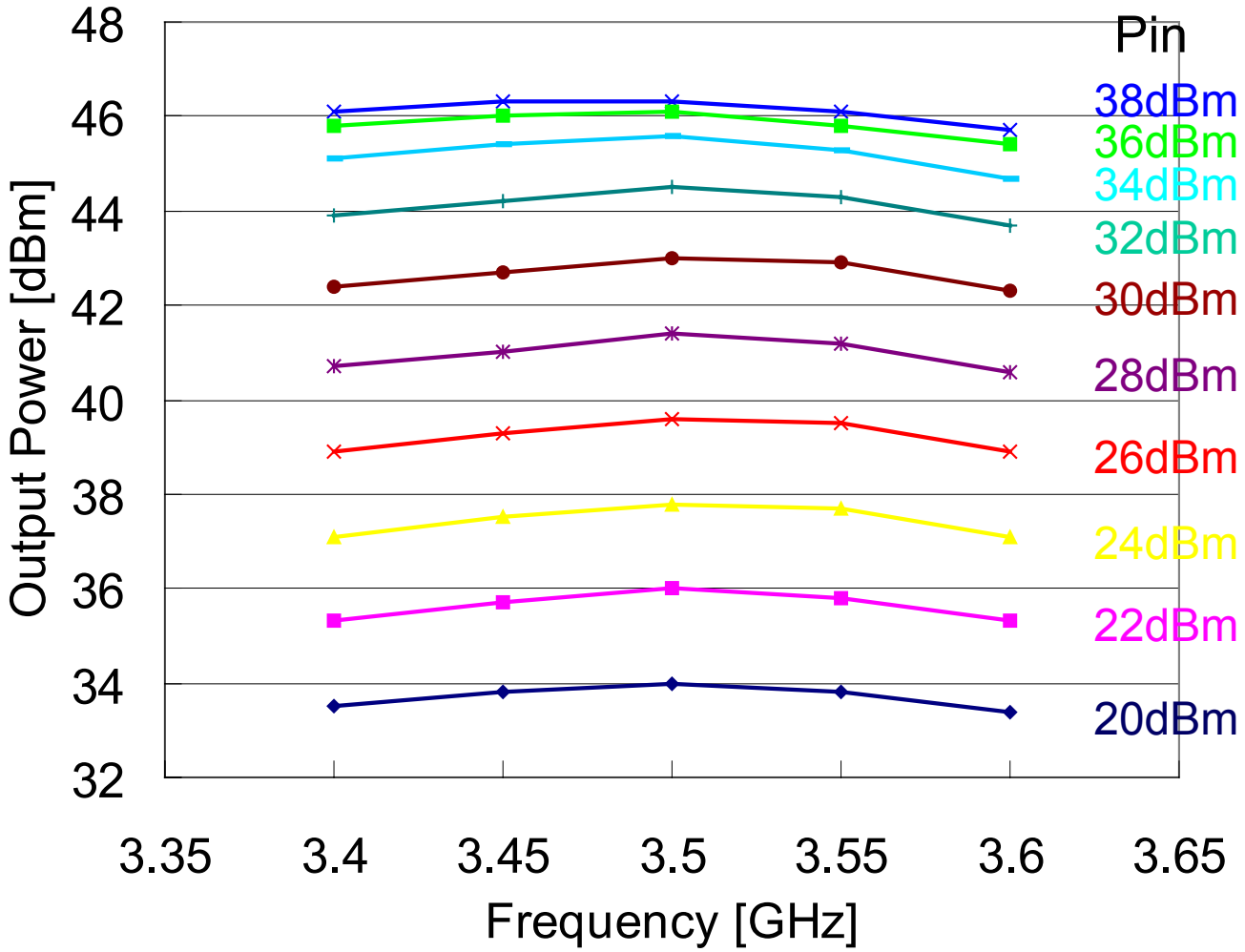
40W Device Pin-Pout

Vds=50V, Idsq=200mA



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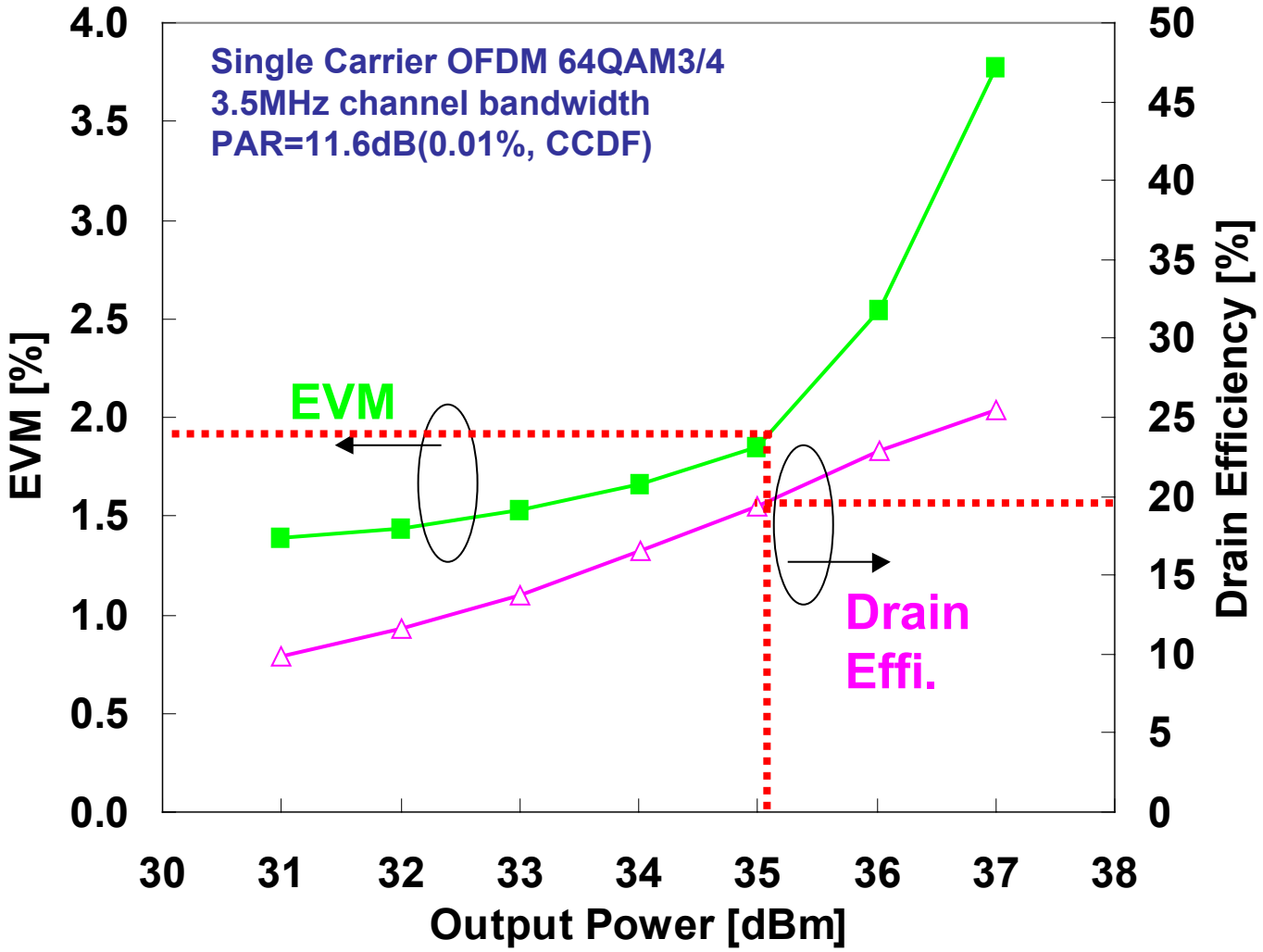
40W Device EVM

Vds=50V, Idsq=200mA, freq.=3.5GHz



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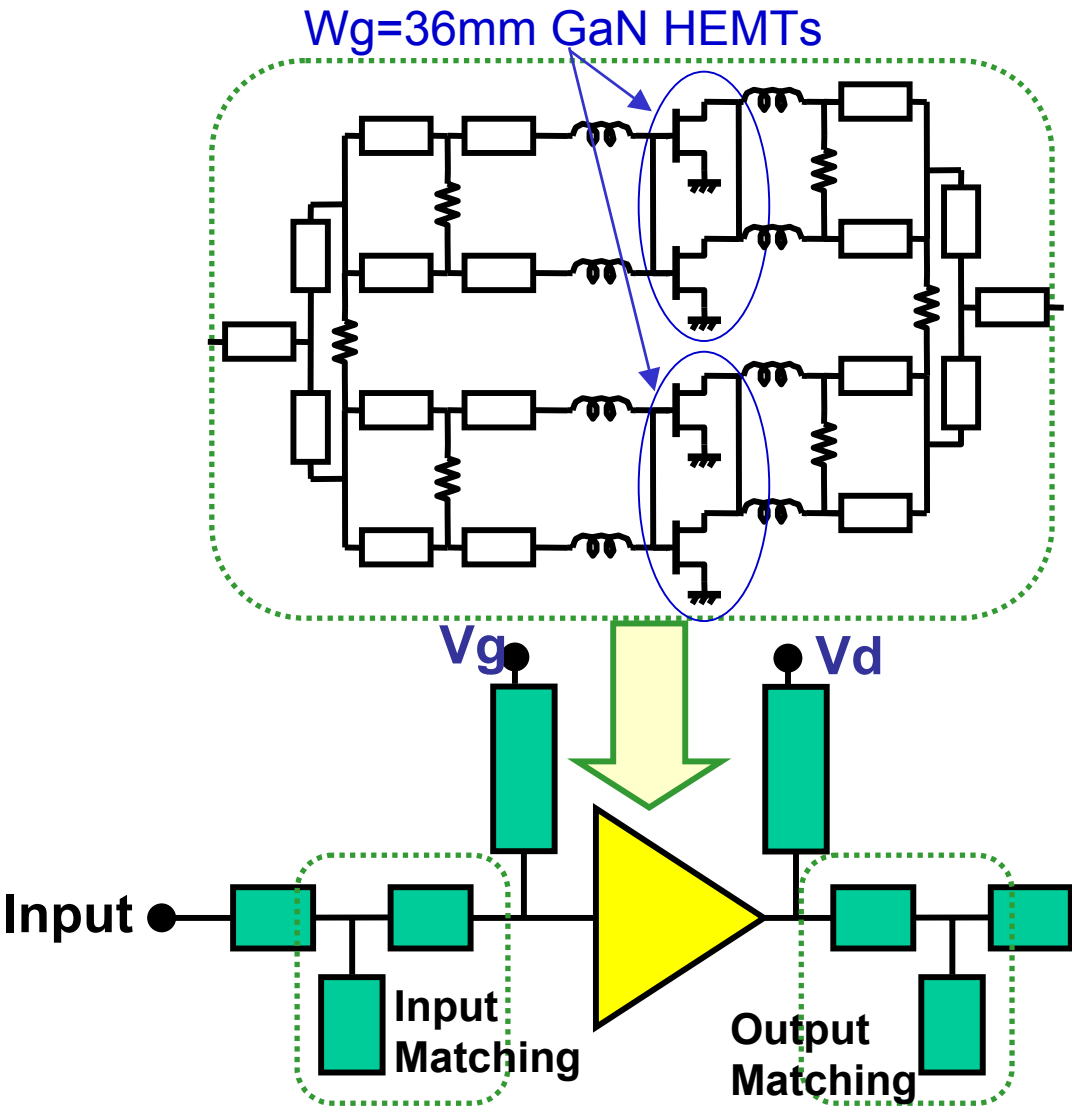
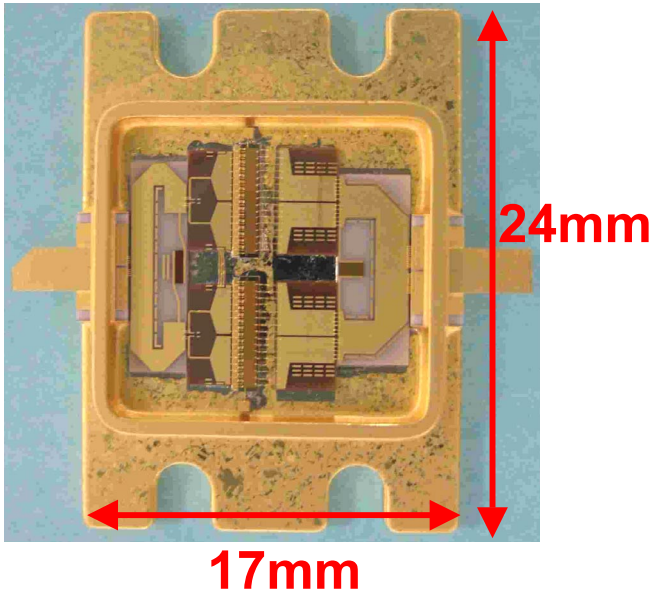
200W Device Design





- Single End Small Package
- Close to 50 ohm matching

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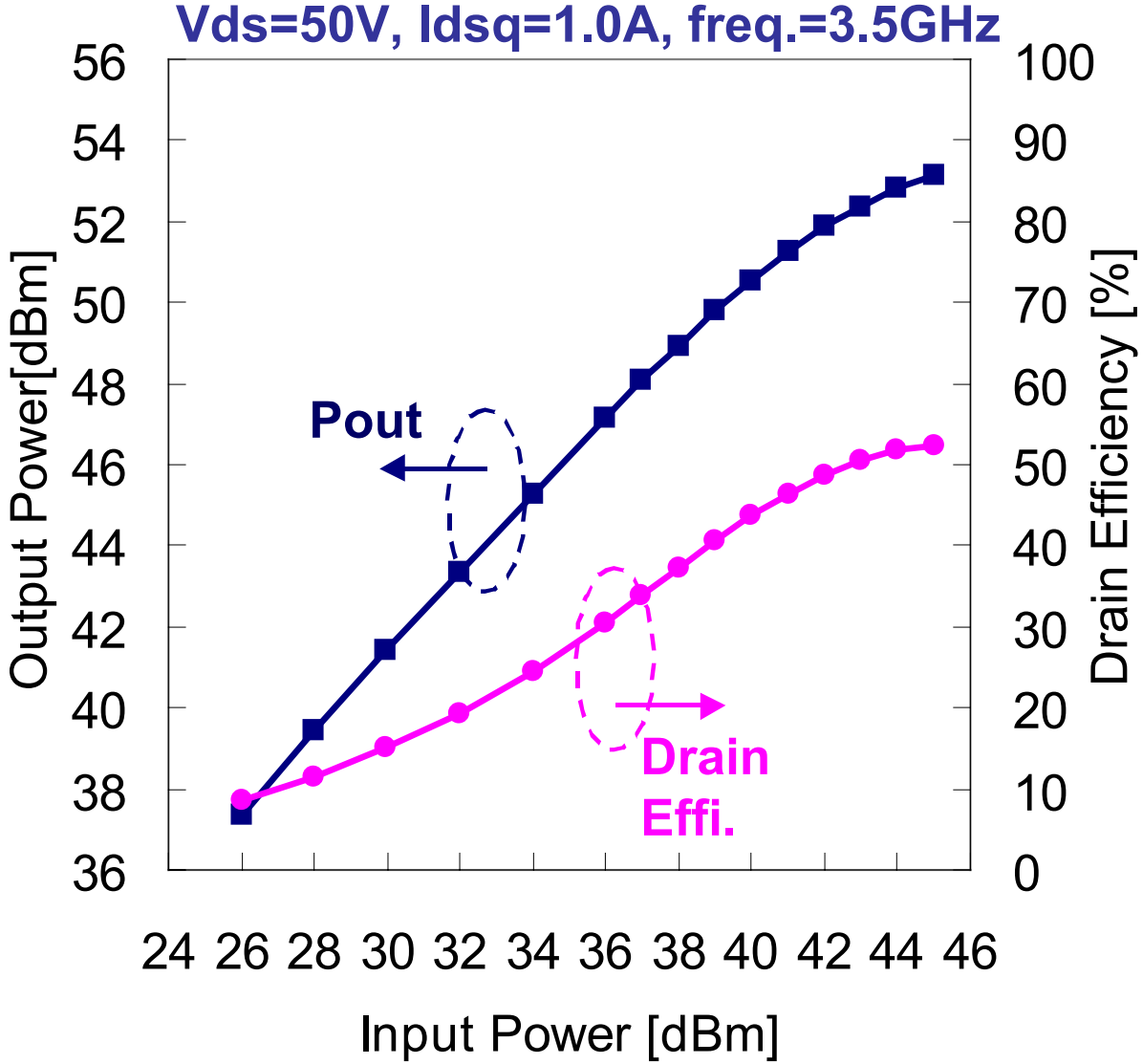
200W Device Pin-Pout(1)



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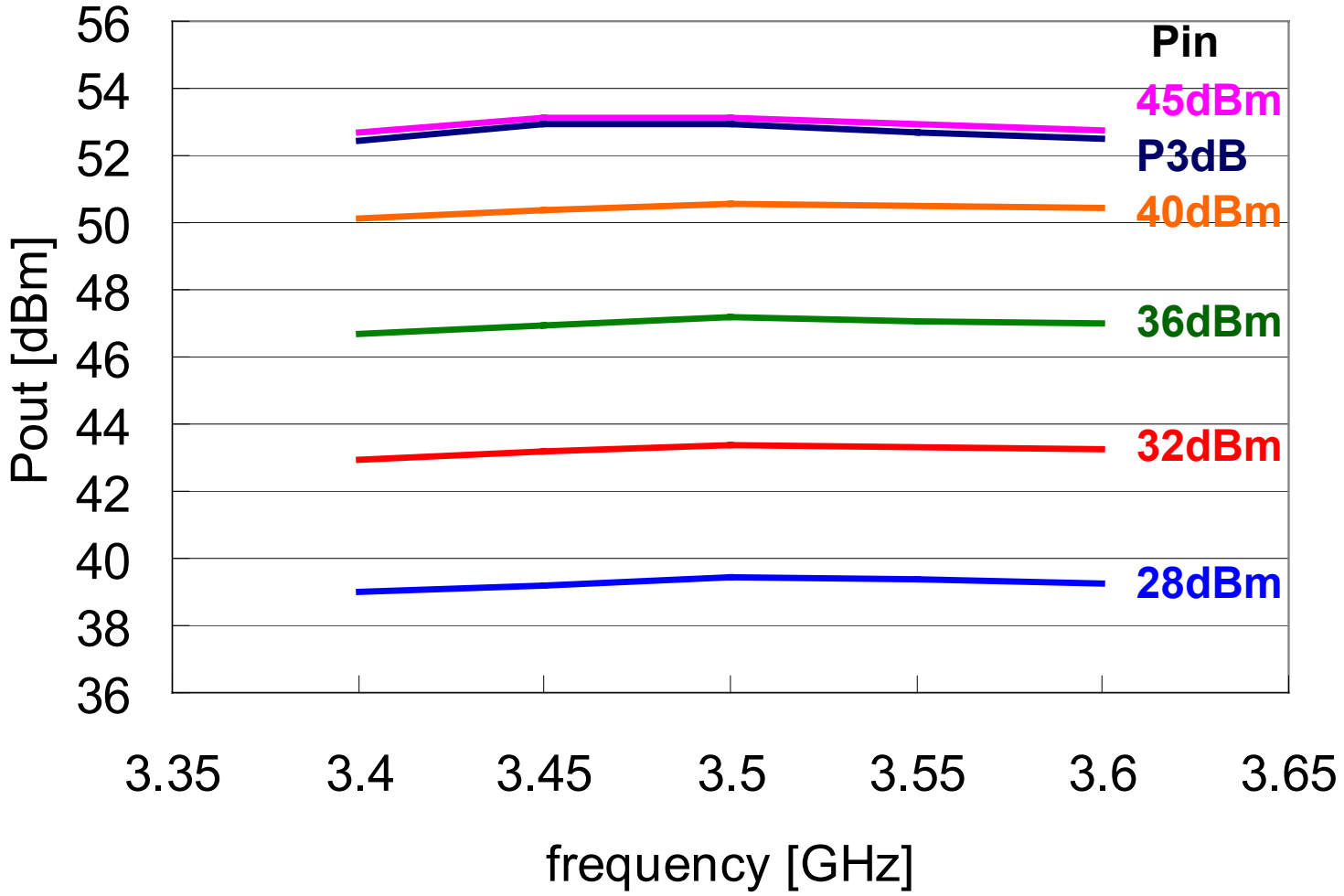
200W Device Pin-Pout(1)

Vds=50V, Idsq=1.0A



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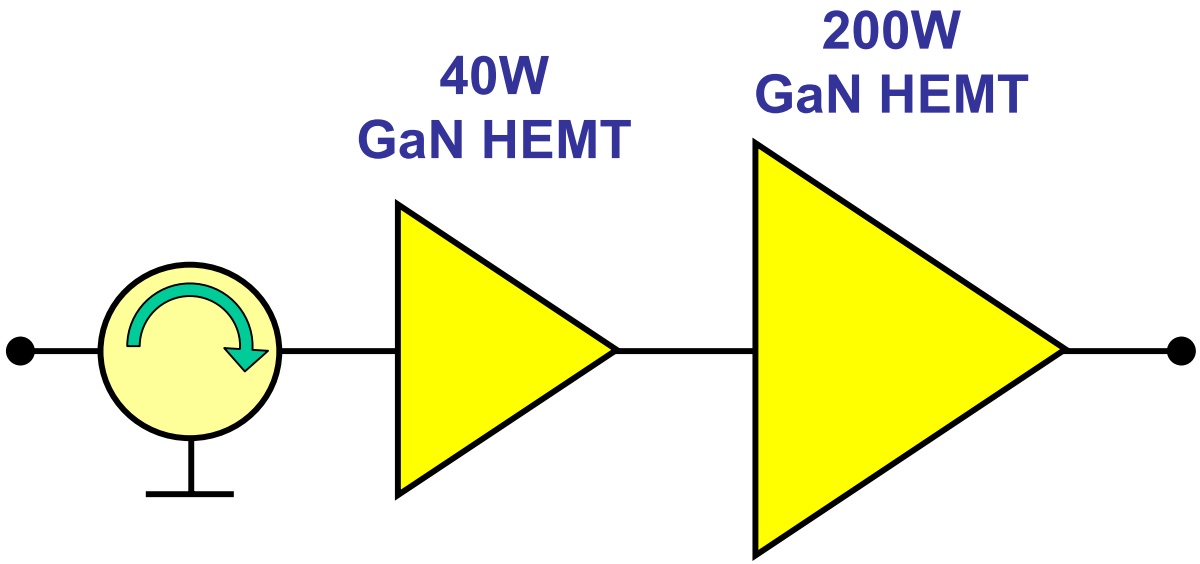
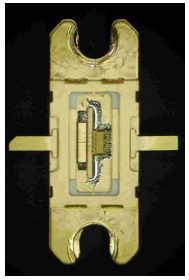
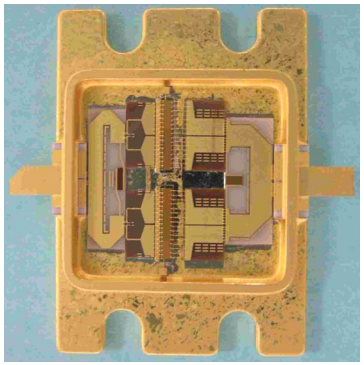
GaN HEMT 2-stage Amplifier







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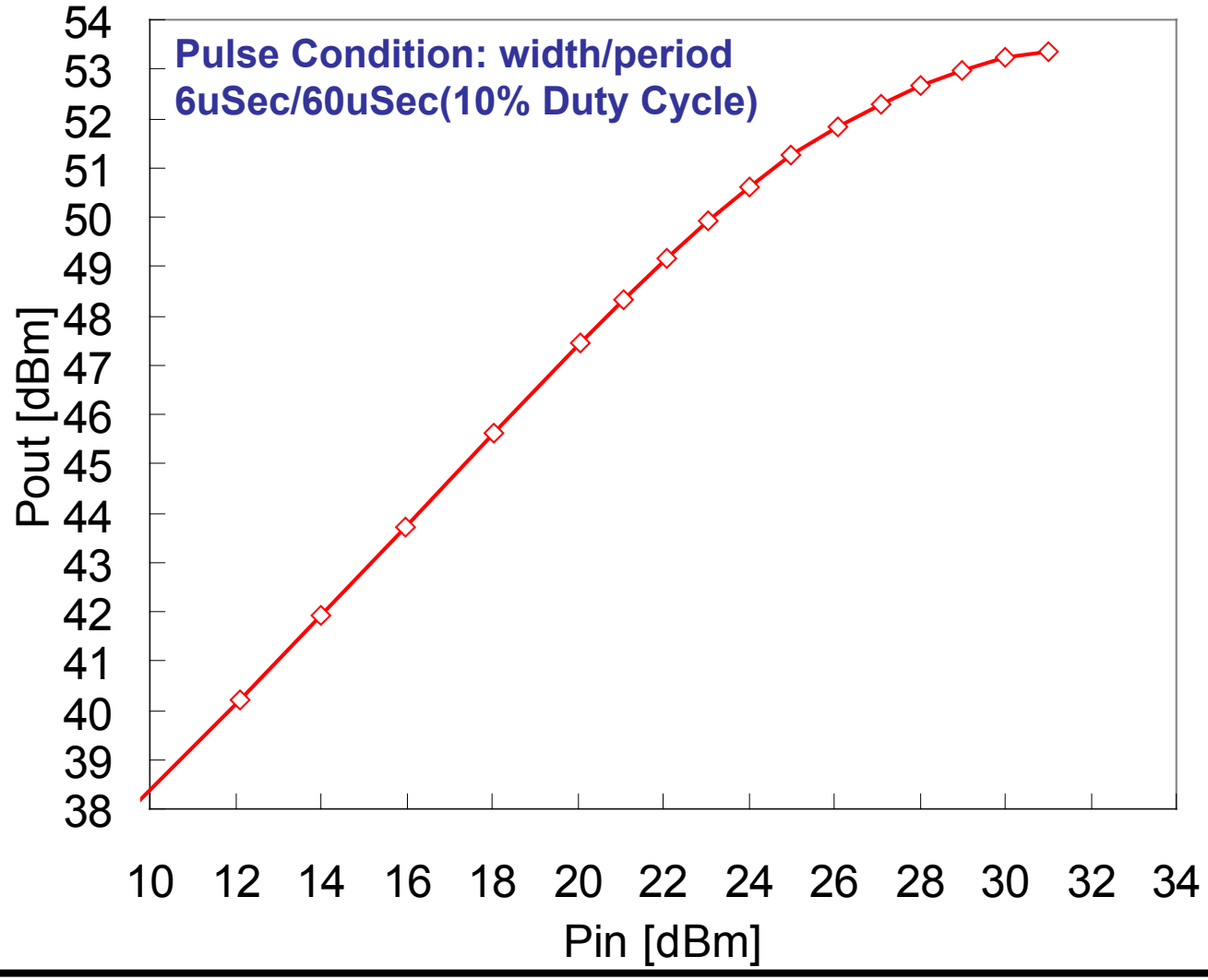
GaN HEMT 2-stage Amplifier Pin-Pout

Vds=50V, Idsq=1.0A(final) and 220mA(driver), f=3.5GHz



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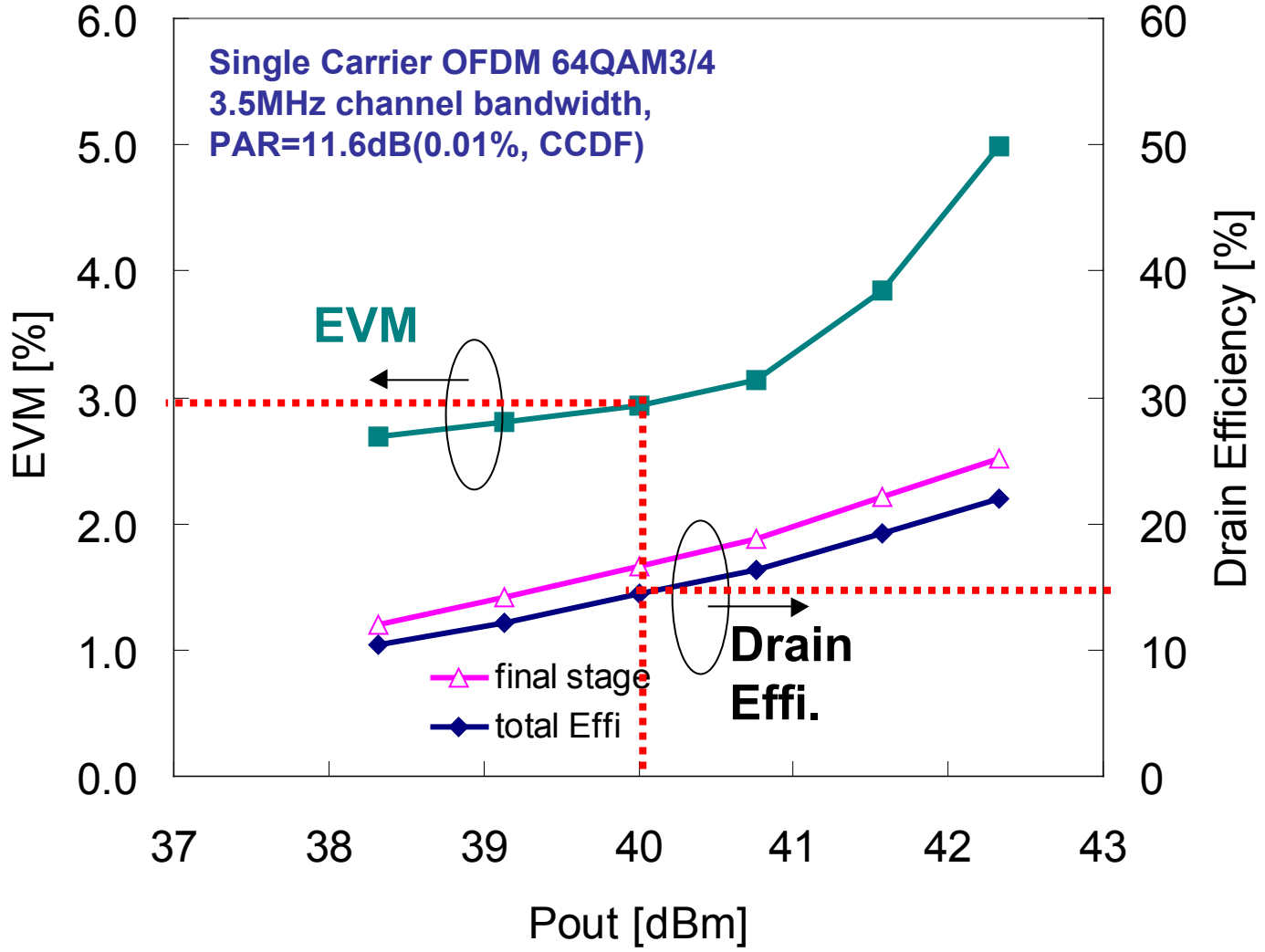
GaN HEMT 2-stage Amplifier EVM

Vds=50V, Idsq=1.0A(final) and 220mA(driver), f=3.5GHz



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Summary

- High power 40W and 200W GaN HEMTs for WiMAX BTS was developed.

  40W: Psat=46.2dBm, Drain Effi.=51%,GL=14dB

  EVM=2.0% at Pave=35dBm, Drain Effi.=20%

  200W: Psat=53dBm, Drain Effi.=51%,GL=11.5dB

- High power 2-stage(40W and 200W GaN HEMTs) Amplifier was demonstrated.

  Psat=53.2dBm, GL=28dB

  EVM=3.0% at Pave=40dBm, Total Effi.=15%

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