SiGe BiCMOS Technologies with RF and Photonic Modules

Multi Project Wafer and
Low Volume Production

About Us

IHP GmbH is a German R&D institution, focused on wireless and broadband communication.

Core competencies are:

- Mixed signal process technology
- RF & digital circuit design
- Communication Systems Design

IHP is running an 8“ pilot line housed in a 1.500 square meter class-3 cleanroom.

Several 0.25 µm and 0.13 µm SiGe BiCMOS technologies are available.

IHP Solutions GmbH is a 100% subsidiary of IHP. IHP Solutions was founded to focus on and grow the transfer of research results (technology transfer) of IHP research activities as well as the commercial partner for value added services along the value chain of IC manufacturing. In the context of IHP’s service offerings IHP Solution is responsible for commercial IC production.

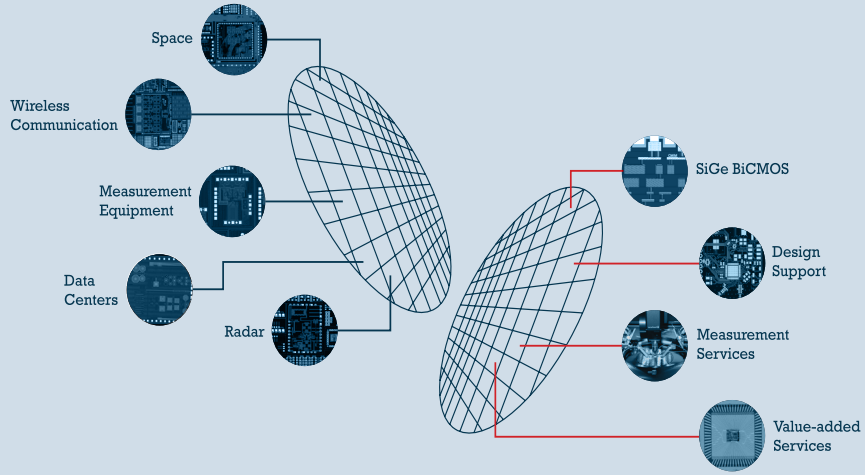
Low Volume Production & MPW Service

IHP offers research partners and customers access to its powerful SiGe BiCMOS technologies and special integrated RF modules.

These technologies are especially suited for applications in the higher GHz bands (e.g. for wireless, broadband, radar).

They provide integrated HBTs with cut-off frequencies of up to 650 GHz.

- For products in fiber optics, aerospace, broadband and wireless communication, radar, data centers, measurement equipment, THz imaging, e-health
- SiGe BiCMOS with leading edge 650 GHz HBTs
- 8 inch wafer fab for research and production in Germany
- Reliable service since 2001



SiGe BiCMOS Technologies for MPW & Prototyping

SG13S	A high-performance 0.13 µm BiCMOS with npn-HBTs up to f_T/f_{max} = 250/340 GHz, with 3.3 V I/O CMOS and 1.2 V logic CMOS
SG13G2	A 0.13 µm BiCMOS technology with higher bipolar performance of f_T/f_{max} = 300/500 GHz
SG25H5_EPIC	A monolithic photonic BiCMOS technology combining 0.25 µm CMOS, high-performance npn HBTs (f_T/f_{max} = 220/290 GHz), and full photonic device set for C/O-band
SG13G3Cu	A 0.13 µm BiCMOS technology with higher bipolar performance of f_T/f_{max} = 470/650 GHz

Standard AI-BEOL

The 0.13 µm process offers five thin and two thick metal layers (TM1:2 µm TM: 3 µm)

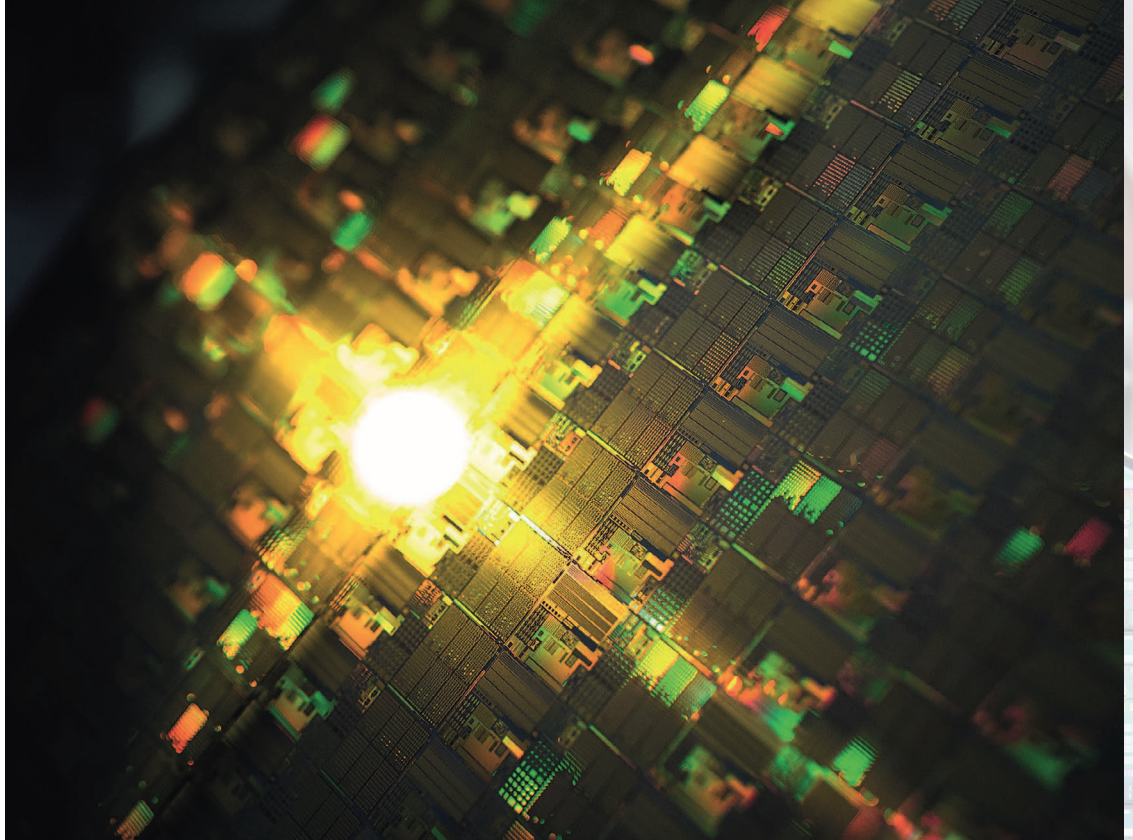
Cu-BEOL model is available

Cadence-based mixed signal Design Kits are available. For high frequency designs an analog Design Kit in ADS can be used. IHP's reusable blocks and IPs for wireless and broadband are offered to support your designs.

The shedule for MPW & Prototyping runs here:

The Following Modules are Available

PIC	Additional photonic design layers together with BiCMOS BEOL layers on SOI wafers
LBE	The Localized Backside Etching module is offered to remove silicon locally to improve passive performance (available in all technologies)
TSV	Module is an additional option in SG13S and SG13G2 technology which offers RF grounding by vias through silicon to improve RF performance
MEMRES	A fully CMOS integrated memristive module based on resistive TiN/ HfO_{2-x}/TiN switching devices in SG13S technology. Process Design Kit including layout and VerilogA simulation model is also available.
TSV+RDL	Module is an additional option in SG13S and SG13G2 technology offers TSV with single redistribution layer on BiCMOS



Key Specification

Feature	SG13S	SG13G2	SG13G3Cu	SG25H5_EPIC
Technology node (nm)	130	130	130	250
f_{max} NPN (GHz)	340	500	650	290
CMOS core supply (V)	1.2, 3.3	1.2, 3.3	1.2, 3.3	2.5
C_{MIM} (fF/µm²)	1.5	1.5	1.5	1.0
Poly Res (Ω/□)	250	275	275	305
High Poly Res (Ω/□)	1300	1360	1360	1600
BEOL	7× Al	7× Al	Cu	5× Al
Varactor (C_{max}/C_{min})	1.7	1.7	1.7	3.3
Q inductor	37*	37*	37*	23.5

*1 nH (with LBE)

Bipolar Transistors

Feature	SG13S	SG13G2	SG13G3Cu	SG25H5_EPIC
NPN1 f_T / f_{max} (GHz)	250 / 340	300 / 500	470 / 650	200 / 280
NPN2 f_T / f_{max} (GHz)	45 / 165		260 / 600	
NPN3 f_T / f_{max} (GHz)			140/500	
NPN1 BV_{CEO} (V)	1.7	1.7	1.4	1.7
NPN2 BV_{CEO} (V)	3.7	2.5	1.8	
NPN3 BV_{CEO} (V)			2.3	
NPN1 BV_{CBO} (V)	5	4.8	3.7	5
NPN2 BV_{CBO} (V)	15	8.5	5.5	
NPN3 BV_{CBO} (V)			7.5	

CMOS Section

Feature		SG25H5_EPIC		SG13S*
Core Supply Voltage (V)		2.5	3.3	1.2
nMOS	V_{TH} (V)	0.6	0.71	0.50
	I_{OUT} (µA/µm)	540**	280	480
	I_{OFF} (pA/µm)	3	10	500
pMOS	V_{TH} (V)	−0.6	−0.61	−0.47
	I_{OUT} (µA/µm)	−230	−220	−200
	I_{OFF} (pA/µm)	−3	−10	−500

* Parameters for SG13G2 and SG13G3Cu are similar
** @ VG = 2.5 V

Passive Section (AL-BEOL)

Feature	SG25H5_EPIC	SG13S	SG13G2	SG13G3Cu
MIM Capacitor (fF/µm²)	1	1.5	1.5	1.5
P+ Poly Resistor (Ω/□)	360	250	260	260
High Poly Resistor (Ω/□)	1600	1300	1360	1360
Varactor C_{max}/C_{min}	3.3	1.7	1.7	1.7
Inductor Q@ 5 GHz	18 (1 nH)	18 (1 nH)	18 (1 nH)	18 (1 nH)
Inductor Q@10 GHz	20 (1 nH)	20 (1 nH)	20 (1 nH)	20 (1 nH)
Inductor Q @ 5 GHz	37 (1 nH)*	37 (1 nH)*	37 (1 nH)	37 (1 nH)

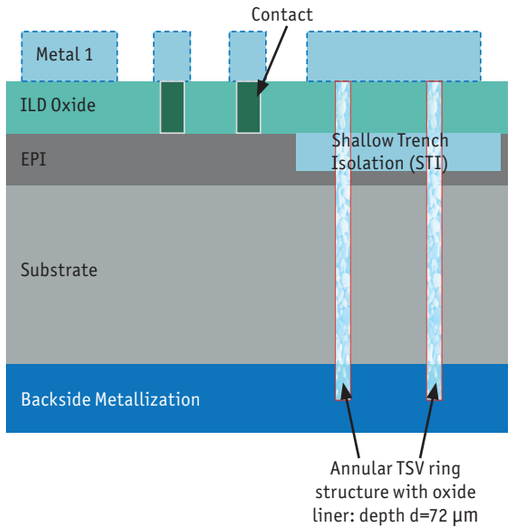
* with LBE

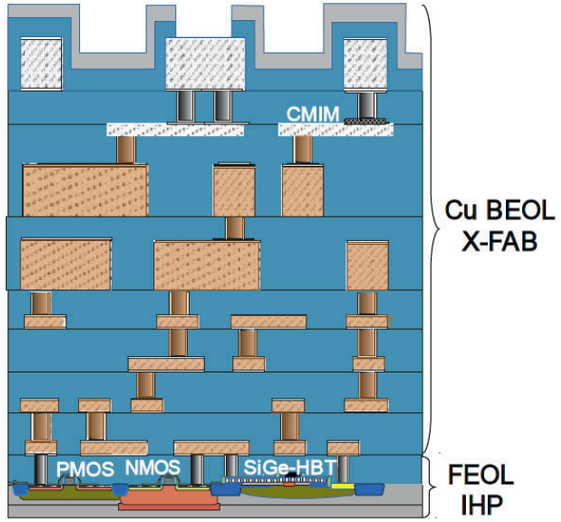
TSV-Module and backside RDL

Through-Silicon Via Module for RF grounding available in SG13 technology.

Single TSVs can provide low GND inductance ≈ 30 pH to improve RF circuit performance.

A backside metallization is provided as chip-to-package interface for die attach.





SG13G/G2 FEOL + XR013 Cu BEOL

Joint foundry offer via IHP Solutions

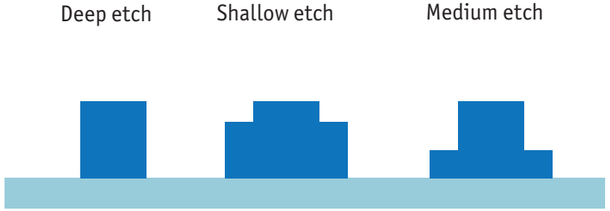
- More than 2 times higher current handling of thin metal lines
- More than 3 times higher current handling of small vias
- 40% higher area density of MIM capasitor

Photonic Integrated Circuit Module

Main features

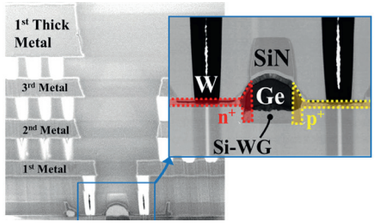
- 220 nm Si on 2 µm SiO_2
- 3 etching depths
- 4 doping levels (p, n, p+, n+)
- 3 + 2 thick Al backend metal layers
- Germanium photo diodes (f_{3dB} > 60 GHz)
- HBTs (f_T/f_{max} = 220/290 GHz)
- Optional localized backside etching
- Complements BiCMOS in SG25H5_EPIC

Wave guides



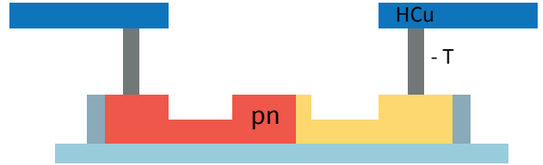
Loss	3.5 dB/cm	1.2 dB/cm	2.5 dB/cm
Core width	450 nm	700 nm	500 nm
Features		Grating etch	p, n, p+, n+possible

Photo diode



- I_{dark} < 200 nA @ (–2 V, 20°C)
- IPKISS3 building block
- GDSII cell
- Responsivity: R_{int}(1550 nm) ≥ 0.7 A/W
  (1310 nm) ≥ 0.8 A/W
- Ge PD -3 dB Bandwidth > 60 GHz (-2 V)

Phase shifter



Typical values

- customized length
- V_π = 4.3 V, V_{bias} = –2.2 V (for 7 mm length)
- C = 1.8 pF

Design Kit

The design kits support a Cadence mixed signal platform.

Analog/Mixed-Signal Flow:

- Verification
  - Cadence and PVS DRC/LVS/QRC
  - Calibre DRC/LVS
- Selected PDKs offer Cadence Voltus FI
- EMX stack for SG13 technology with Al-BEOL and Cu-BEOL
- Empire support for all design kits
- ADS support via Golden Gate/RFIC dynamic link to Cadence available
- Sonnet support for all design kits

Digital Design Flow:

- Digital CMOS libraries and IO cells for 0.13 µm CMOS and 0.25 µm CMOS are available: Behavorial Models (Verilog), Timing Files (LIB) and Abstracts (LEF)
- Simulation: ModelSim (Mentor Graphics), Incisive Enterprise Simulator – IES (Cadence)
- Formal Verification: Formality (Synopsys)
- Scan Insertion and Test Pattern Generation: DFT Complier/TetraMax (Synopsys)
- Place & Route: Encounter Digital Implementation System (Cadence)
- OA views of digital libraries are available for mixed-signal flow
- Power Analysis: PrimeTime with PrimePower Option (Synopsys)
- Static Timing Analysis: PrimeTime (Synopsys)

Models	SG25H5 EPIC	SG13S	SG13G2	SG13G3
PSP	x	x	x	
MOSVAR		x	x	
HSIM		x	x	x*
VBIC/HICUM	x	x	x	

EM simulations	SG25H5 EPIC	SG13S	SG13G2	SG13G3
Keysight momentum		x	x	
Sonnet		x	x	
EMX		x	x	x

SG13G3: $VBIC_{max}$

Design platforms	SG25H5 EPIC	SG13S	SG13G2	SG13G3
Cadence Virtuoso & Virtuoso XL	x	x	x	x
Cadence Spectre & Spectre RF	x	x	x	x
Cadence VPS & Voltus FI		x	x	
Keysight ADS	x	x	x	x
Mentor Calibre DRC/LVS		x	x	x
TexEDA RFIC Studio	x	x	x	
IPKISS3	x			

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