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SiGe, GaAs and InP Transimpedance Amplifiers for 10/12.5/40 Gb/s Optical Receivers

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Introduction

As the optical networking market shifts focus to meet the demands of the access and datacom applications, different requirements for transimpedance amplifiers (TIAs) are evolving. In particular, short-reach applications, such as MAN and 10.3 Gigabit Ethernet, require lower cost, a lower voltage supply and reduced dc power levels. The long-haul applications still require higher receiver sensitivity, overload and transimpedance gain, but at reduced cost and lower dc power levels. The requirements for the high speed 40 Gb/s market are even more challenging. The disparate TIA requirements brought on by the evolving fiber market cannot be optimally satisfied by one sole technology or design.

Sirenza Microdevices (SMDI), a fabless designer and supplier of RF components, introduces a family of 10 and 40 Gb/s TIAs, which feature our own innovative design IP and exploit the inherent properties of SiGe, GaAs and InP semiconductor technologies. SMDI is positioning itself as a provider of optimal solutions for future requirements in the optical telecom and datacom markets.

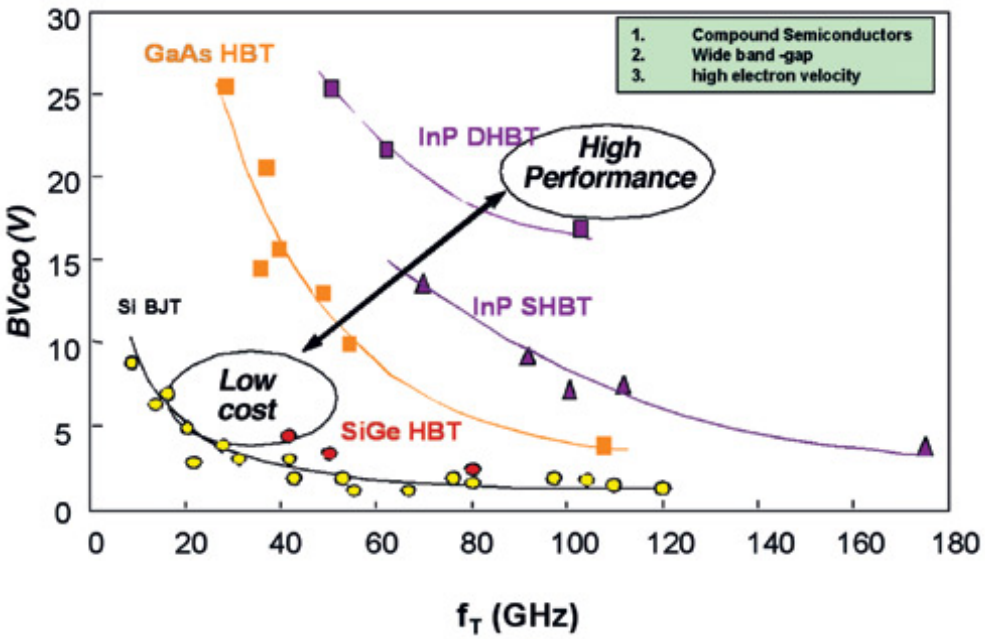

Figure 1: Breakdown versus fT for various Bipolar Technologies

SiGe, GaAs and InP HBT Transimpedance Amplifier Solutions

Fundamentally, the performance and cost of the TIA are determined by the semiconductor technology. Bipolar junction transistor (BJT) technologies are attractive for broadband fiber optic applications because of their superior analog characteristics and raw speed. Heterojunction bipolar transistor (HBT) technology, an enhanced version of BJT, is built with heterojunction materials such as SiGe, GaAs and InP, which possess

superior electron transport properties. Higher breakdown voltages and device cut-off frequencies are achieved relative to conventional silicon BJTs. **Figure 1** illustrates a plot of transistor breakdown voltage versus cut-off frequency for various BJT technologies. The inherent material bandgap and electron velocity characteristics determine the fundamental trade off between practical operating voltage and device speed. For each given technology, the transistor may be designed to obtain higher ft at the expense of operating voltage or until impractical breakdowns are reached. As designs migrate toward the more expen-sive GaAs and InP compound semiconductor technologies, higher transistor fts are available with moderate breakdown voltages that are better suited for the higher speed 12.5 Gb/s and 40 Gb/s telecom applications. In contrast, the less expensive Silicon and SiGe technologies are well suited for the narrower band 10 Gb/s datacom applications, which includes 9.95 Gb/s OC192/STM-64 SONET/SDH, 10.3 Gb/s Gigabit Ethernet and 10.5 Gb/s Fibre Channel.

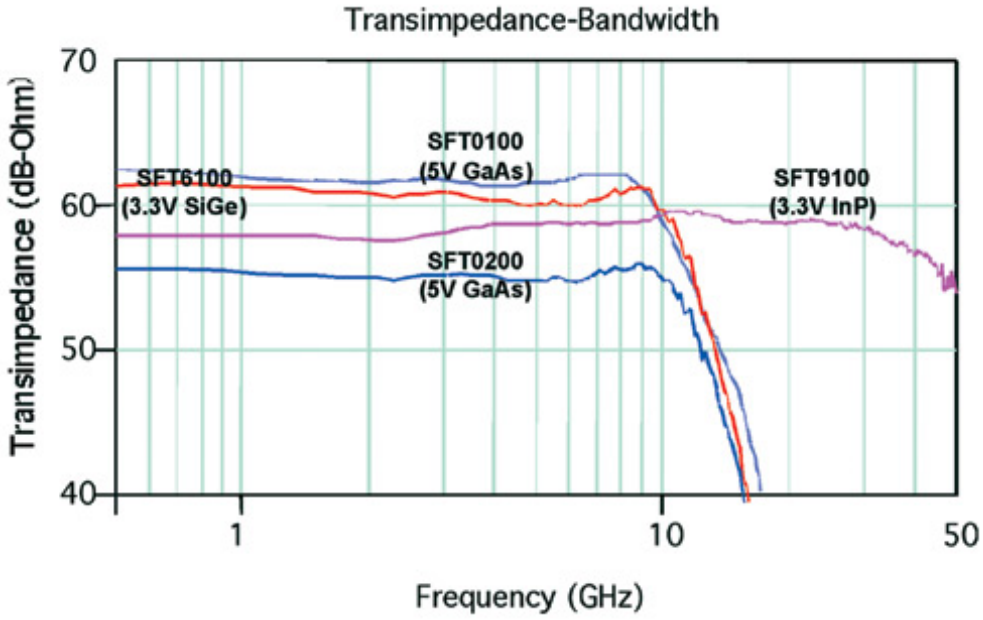

Figure 2

Table I summarizes the general properties of the HBT TIA semiconductor technologies used in Sirenza's TIA product family. SiGe HBT offers lower cost compared to GaAs and InP technologies. It can also be fabricated with cut-off frequencies of 75 GHz or above and still maintain respectable device breakdown voltage. Another favorable attribute of SiGe HBT technology is its ability to operate with a low voltage supply of 3.3V. This results in higher gain-bandwidth product per dc power compared to GaAs, making it more attractive for low cost, low voltage 10 Gb/s datacom applications.

GaAs HBT offers the lowest device thermal and shot noise, which ultimately results in superior receiver sensitivity. In addition, GaAs HBTs have optional backside vias. These vias allow for better electrical and thermal grounding, and eliminate down-bond inductance. Bond wire RF parasitics can inflict bandwidth and noise performance degradation, as exhibited in SiGe TIAs. Consequently, vias can ease the assembly of TIAs in receiver products, by eliminating the need for some of the bond wires, making this solution attractive for high volume production. When high performance is imperative and 5V operation is allowed, GaAs HBTs offer superior dynamic range ~ 21 dB for 10 and 12.5 Gb/s telecom applications.

The inherent speed and high gain-bandwidth and dc efficiencies of InP make it the preferred technology for 40 Gb/s receivers. Compared to SiGe, it has demonstrated superior gain, bandwidth and dc efficiency. (**Figure 1**) demonstrates InP HBTs inherently superior ft - breakdown product characteristic.

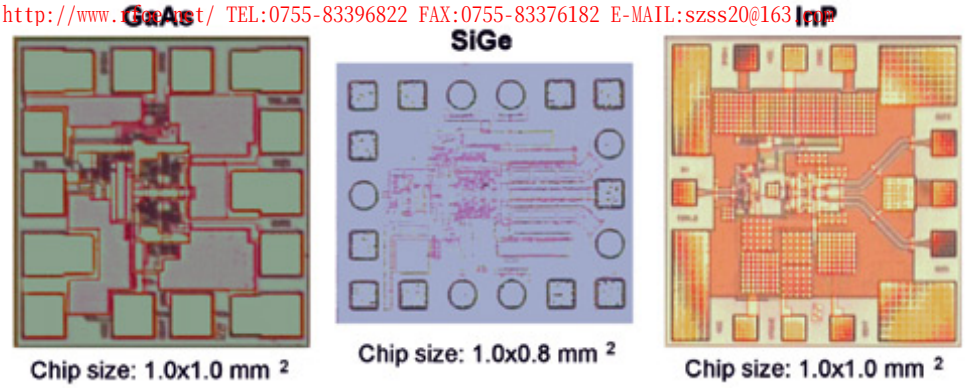

Figure 3: Chip Photographs of Sirenza's TIA products

10 and 40 Gb/s Transimpedance Amplifier Products

The transimpedance responses of Sirenza's SiGe, GaAs and InP HBT TIAs are given in **Figure 2**. Photos of our TIA chip die are shown in **Figure 3**. The SFT6100 is a SiGe TIA that operates from a single 3.3V supply and offers a differential transimpedance gain of 2200 ohms with a corresponding 3 dB bandwidth of 9.5 GHz. The SFT0100 and SFT0200 are high and low transimpedance GaAs HBT TIAs, intended for wide dynamic range for 10 and 12.5 Gb/s operation. The SFT0100 operates from a single 5V supply and provides a transimpedance of 2200 ohms and a broad bandwidth of 10.5 GHz. The SFT0200 also operates from a single 5V supply, offers a lower transimpendance gain of 1100 ohms, but covers a wider bandwidth of 11.5 GHz, making it more suitable for 12.5 Gb/s FEC applications. Both GaAs SFT0100 and SFT0200 TIAs come with backside vias, which help reduce wirebond parasitics dramatically, simplifying the assembly of the TIA into TO-CAN packages.

Sirenza also offers the SFT9100, an InP HBT TIA for 40 Gb/s applications, which achieves an impressive 1500-ohm transimpedance gain and a 3 dB bandwidth of 45 GHz. SMDI's TIA products are summarized in **Tables 2 and 3**.

Technology	Cost	Device Speed, fT (GHz)	Practical Supply Operation	Thermal Noise (Ribsheet)	Shot Noise	Backside VIAs	Gain-BW per DC power (GHz/mW)
SiGe	Low	75	3.3V	Med	Low	No	1.75
GaAs	Med	55	5V	Low	Low	Yes	1
InP	High	150	3.3V	Low	Med	No	3.75

Table 1: Summary of HBT TIA Technologies

Part Number	Vcc (v)	Is (mA)	Gain Diff (Ω)	Bandwidth (GHz)	Sensitivity (dBm)
SFT-0100*	+ 5	52	2200	10.5	- 18.5

* Photo-diode current monitor and adjustable dynamic range included

Table 2: SFT Series – Transimpedance Amplifiers for Fiber-Optic Receivers

Part Number	Vcc (v)	Is (mA)	Gain Diff (Ω)	Bandwidth (GHz)	Sensitivity (dBm)
SFT-0200	+ 5	52	1100	11.5	- 18.5
SFT-5100	+ 3.3	44	2000	8.5	- 18.0
SFT-6100	+ 3.3	44	2200	9.5	- 18.0
SFT-9100	+ 3.3	54	1500	45.0	- 14.0

Table 3: Advance Products – More TIAs for 10/12.5/40 Gb/s Receivers

Wide Dynamic Range and other TIA Features

Table 4 lists the available features of our Sirenza TIA products. These TIAs are based on a patented wide dynamic range circuit topology, which offers a dynamic range as high as ~21 dB (SFT0100). Other features

include duty cycle distortion reduction, single positive supply operation, dc restore and a photo current monitor that facilitates fiber alignment and signal detection.

Features/Technology	SiGe (SFT5100) (SFT6100)	GaAs (SFT0100) (SFT0200)	InP (SFT9100)
Low Voltage	X		X
Wide Dynamic Range		X	
Photo Current Monitor	X	X	X
Duty Cycle Distion Reduction	X	X	X
Tuanble Tz bandwidth*			X
DC Restore	X	X	X
Single Supply	X	X	X
Backside VIAs		X	
40 Gb/s Operation			X
RZ/FEC-Bandwidth		X	X

Table 4: TIA Feature

Distinct features include:

- **3.3V supply operation with both SiGe and InP TIAs**
- **Backside vias for easy TO-CAN assembly**
- **40 Gb/s operation**
- **Tunable transimpedance band width control (patent pending) for InP TIAs.**

Sirenza's innovative approaches in TIA design are reflected below. With the introduction of the SFT series of TIAs, Sirenza is establishing itself as a leading supplier of very linear, wide dynamic range front-end components. We will continue to invest in advanced product development and in our IP portfolio to better position us for present and future markets.

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