FACT SHEET NIJ004

Double Polysilicon – the technology behind silicon MMICs, RF transistors & PA modules

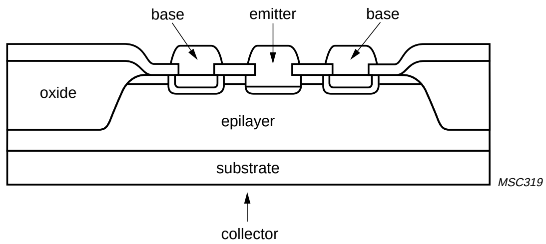
Higher frequencies and greater levels of integration for mobile communications

Explosive growth in the mobile communications market and the use of ever-higher frequencies have fuelled demand for low-voltage, high-performance, RF wideband transistors, amplifier modules and MMICs (Monolithic Microwave ICs). Making these devices highly cost effective, we now offer double-polysilicon technology — a better, silicon bipolar RF process that greatly improves the performance of low-voltage RF products, and enables the manufacture of silicon MMICs.

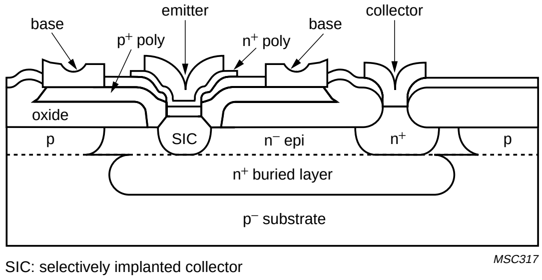
The process technology

The “double-poly” diffusion process makes use of an advanced, self-aligned transistor technology that is vastly superior to existing bipolar technologies (see Figs 1 & 2). With double poly, a *polysilicon* layer is used to diffuse and connect the emitter while another polysilicon layer is used to contact the base region. And, via a buried layer, the collector is brought out on the top of the die. Key advantages over conventional bipolar technology are:

- **Higher transition frequencies**
  A polysilicon emitter makes it possible to obtain a very steep doping profile, for a very thin base region. This outperforms the more conventional implanted emitter on transition frequency.
- **Higher power gain**
  The self-aligned transistor structure significantly reduces parasitic feedback capacitance, drastically improving RF power gain. This is obtained by using small polysilicon base contacts and a selective implanted collector. Feedback capacitance is further reduced because the base bond-pad is on the emitter area (not the collector area) owing to the buried layer structure.
- **Lower noise operation**
  Using self-aligned technology with submicron emitters provides a low base resistance, essential for low-noise operation.
- **Better heat dissipation**
  With the emitter-connected substrate, heat is transferred through the grounded emitter leads — a significant benefit to circuit and board designers.



Existing advanced bipolar transistor



Self-aligned double-polysilicon buried npn transistor

Fig.1 In the advanced, self-aligned double-poly structure, the emitter is diffused from an arsenic-doped polysilicon layer to obtain accurate control of the base width (as thin as 70 nm). The narrow base, combined with a selectively implanted collector, results in devices with very high transition frequencies.

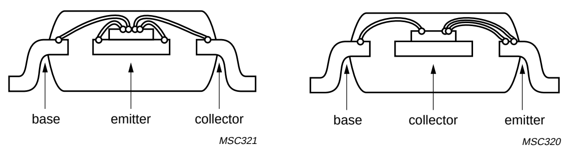


Fig.2 In double-polysilicon devices (left), the emitter is connected to the substrate, unlike conventional bipolar devices (right). This simplifies heatsinking and shortens bond wires for improved performance.

- **Simpler matching**
  A high transition frequency and low feedback capacitance increase the transistor’s input impedance, simplifying matching to preceding driver stages.
- **Higher integration for MMICs**
  The new process technology lends itself to small-scale integration, so additional components can be easily integrated on-chip.

Applications

Though the stimulus for developing this technology was the cellular and cordless markets, (in particular for low-noise amplifiers, mixers and power amplifier circuits operating at 1.8 GHz and higher), its exceptional performance clearly makes it well-suited for use in other high-performance RF front-ends, e.g. pagers and satellite TV tuners. Wherever the ultimate in small-signal RF performance is required at a competitive price, double-polysilicon transistors, power amplifier modules and MMICs are the only serious choice.

Performance

Double poly technology is used in the BGA2001/2/3; BGA2022; BGA2031 MMICs, BFG403W/410W/425W/480W/21W broadband 5th generation wideband transistors, and the BGY240S/241/212/280 families of RF power amplifier modules. Figures 3 & 4 compare typical power gains and noise performance with previous bipolar technologies.

Double polysilicon — feature summary

- Transition frequency >23 GHz
- Very high power gain ($G_{max.}$ 22 dB at 2 GHz)
- Low noise figure (typ. 1.3 dB at 2 GHz)
- Low current consumption
- Optimized for low supply voltages
- High reverse isolation
- High efficiency
- High linearity.

Continuous improvement through technology innovation

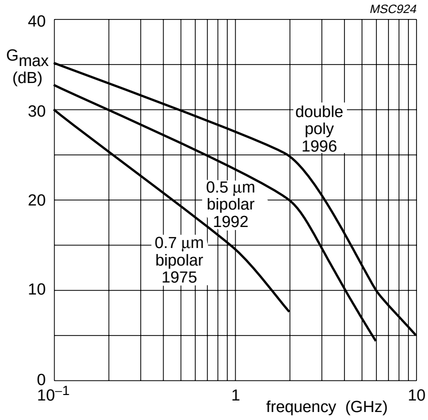


Fig.3 Power gain

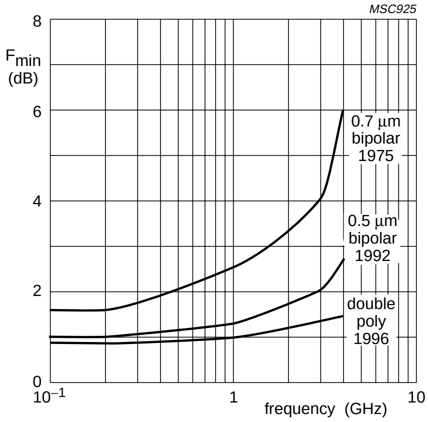


Fig.4 Noise figure

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SCS60

Printed in The Netherlands

Date of release: November 1998

Document order number: 9397 750 04787

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