InP/GaAsSb DHBT with record more than 700GHz power-gain cut-off

Base contact resistance has been reduced by in-situ argon sputtering treatment of the GaAsSb base before metal deposition.

The Swiss Federal Institute of Technology (ETH-Zürich) has reported a record power-gain cut-off frequency, f_{MAX}, of 700GHz for a double heterostructure bipolar transistor (DHBT) based on indium phosphide (InP) and gallium arsenide antimonide (GaAsSb) [Ralf Flückiger et al, Appl. Phys. Express, vol7, p034105, 2014].

The epitaxial material structure (Figure 1) was achieved using metal-organic chemical vapor deposition (MOCVD) on 2-inch semi-insulating InP substrates. The heterostructure used staggered gap 'Type II' InP/GaAsSb junctions where the band discontinuities are in the same direction. Such structures allow the use of a simplified pure InP collector, giving good thermal conductivity and high breakdown voltages.

The transistors were constructed as 'triple-mesa' devices with 0.4μm-wide emitter and base, achieved with inductively coupled plasma and wet etch processes. The emitter–base junction area was 0.3μmx4.4μm.

The emitter and base electrodes consisted respectively of titanium/platinum/gold and palladium/nickel/platinum/gold. The surface of the

Emitter contact	$Ga_{0.75}In_{0.25}As$	5nm
Graded emitter contact	$Ga_zIn_{1-z}As$	10nm
Emitter contact	$Ga_{0.47}In_{0.53}As$	20nm
Emitter	InP:Si	130nm
Emitter	InP:Si	5nm
Graded emitter	$Ga_yIn_{1-y}P$:Si	10nm
Emitter	$Ga_{0.22}In_{0.78}P$:Si	5nm
Graded base	$GaAs_xSb_{1-x}$	20nm
Collector	InP:S	125nm
Pedestal	InP:S	50nm
Etch stop	$Ga_{0.40}In_{0.60}As$:Si	20nm
Buffer	InP:S	300nm
Substrate	Semi-insulating InP	

Figure 1. Epitaxial layer sequence. The gradings in the upward direction were x = 0.41–0.59, y = 0.22–0.00, and z = 0.47–0.75.

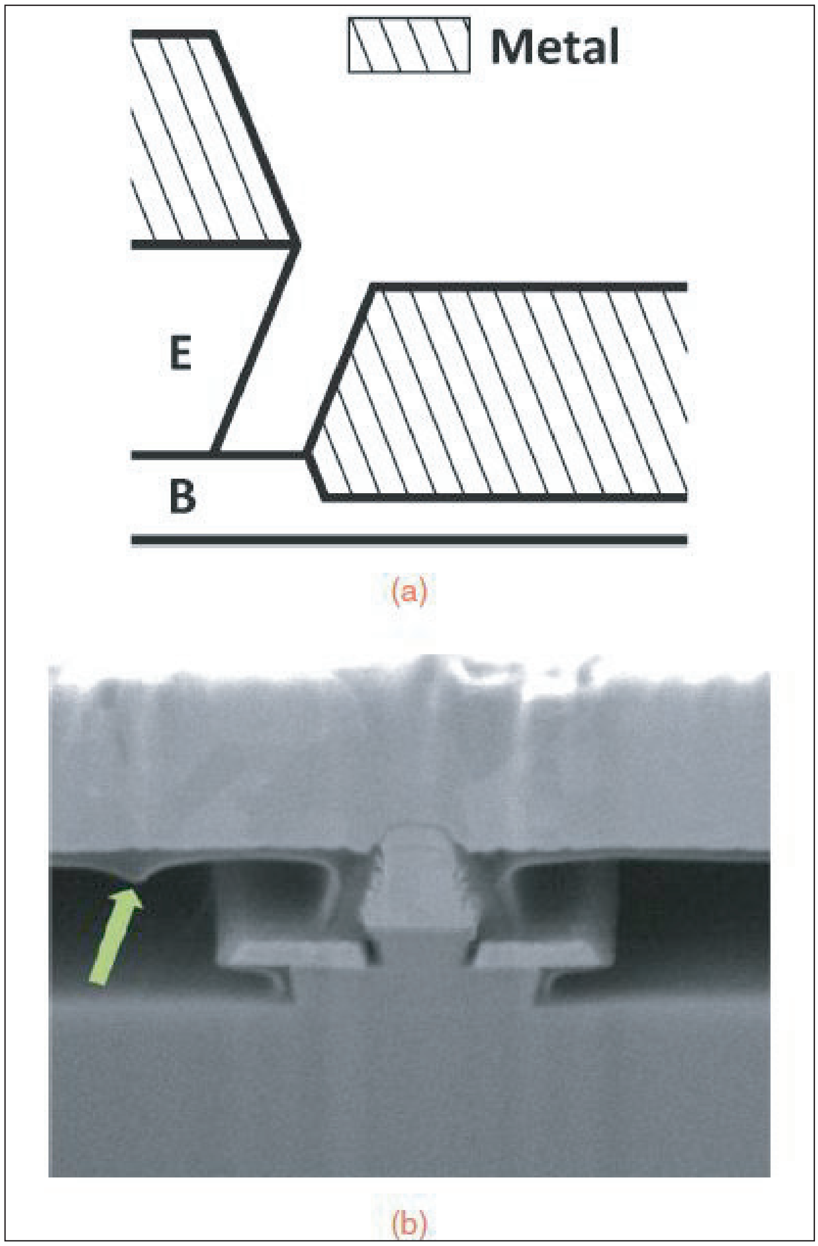

Figure 2. (a) Schematic representation of emitter and base contact. The emitter contact acts as a mask for argon sputtering and protects base access region. (b) Scanning electron micrograph of focused-ion-beam cross section of representative DHBT. Arrow indicates residuals of Teflon planarization.

GaAsSb base was treated using an in-situ argon sputtering process before metal deposition (Figure 2). The treatment is found to reduce contact resistivity from $\sim 10^{-6}\Omega\text{-cm}^2$ to $\sim 10^{-9}\Omega\text{-cm}^2$. The process removed about 10nm of GaAsSb, including oxidation layers. The emitter was protected by the metal contact electrode layers that acted as a self-aligned mask.

Passivation of the emitter and base sidewalls was provided by plasma-enhanced chemical vapor deposition (PECVD) of silicon nitride. A low-temperature Teflon-based etch-back process was used to planarize the devices before the deposition of probe pads.

The RF performance was measured between 0.2GHz and 40GHz, giving estimated current- (f_T) and power-gain (f_{MAX}) cut-offs of 442GHz and 701GHz, respectively, at a collector–emitter voltage (V_{CE}) of 1.2V. With a higher V_{CE} of 1.6V, the corresponding estimates were 429GHz and 715GHz.

The researchers write: "The present devices show a ~100GHz higher f_{MAX} than those previously reported with the same epitaxial layer structure."

The DC gain of the device was 11 and the common-emitter breakdown voltage (BV_{CEO}) was over 5V. ■

http://iopscience.iop.org/1882-0786/7/3/034105/article

Author: Mike Cooke