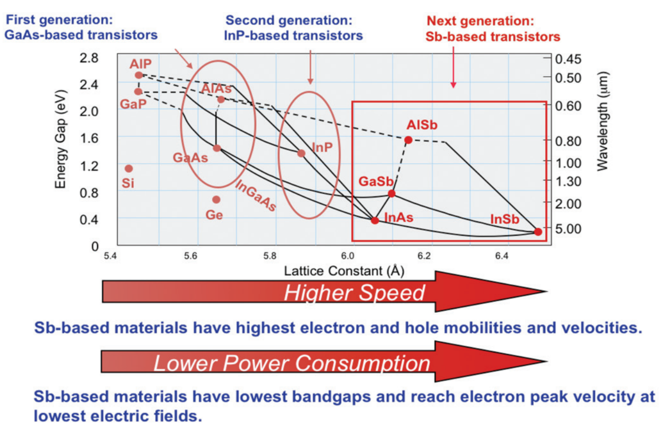
Ultra-Low-Power III-V Electronics

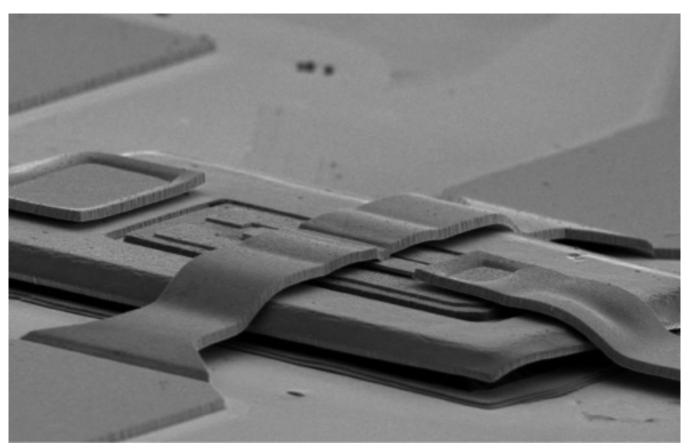
ABCS for Radar, Communications, and Sensing: Naval Research Laboratory scientists and engineers are investigating antimonide-based compound semiconductors (ABCS) for use in low-power electronics applications. ABCS materials have intrinsic performance advantages due to the attractive electron and hole transport properties, narrow bandgaps, low ohmic contact resistances, and unique band-lineup design flexibility. These advantages can be particularly exploited in applications where high-speed operation and low power consumption are essential, which include large-scale active-array space-based radar, communications, imaging, sensing, and high-data-rate transmission.



HEMTs: For example, quantum wells of InAs clad by AlGaSb exhibit room-temperature electron mobilities of 20,000–30,000 cm^2/V-s. They can form the basis of high-electron mobility transistors (HEMTs) which operate at high speeds with low power consumption. Unity current-gain (f_T) and power-gain (f_{max}) cut-off frequencies of 200–300 GHz have been achieved for 100 nm gate lengths, comparable to state-of-the-art InGaAs/InAlAs/InP HEMTs. The potential advantage over InP-based HEMTs is in power consumption. InAs HEMTs can reach an f_T of 100 GHz at a drain voltage of only 100 mV, compared to 300 mV for InP HEMTs. As a result, low-noise amplifier (LNA) circuits based on InAs HEMTs consume 3 to 10 times less power than GaAs- or InP-based LNAs at the X, Ka, and W bands. This technology was transferred from NRL to Northrop Grumman Corporation.

HBTs, HBVs, and p-n Diodes: NRL researchers have also used ABCS materials to demonstrate heterojunction bipolar transistors (HBTs), heterostructure barrier varactors (HBVs) for use as frequency multipliers, and p-n diodes for THz mixer applications. Recently, there has been considerable interest in the potential of III-V materials for advanced logic applications. Complementary circuits with n- and p-channel field effect transistors (FETs) are desirable for minimizing static power consumption. Unfortunately, hole mobilities in III-Vs are generally much lower than electron mobilities. For example, GaAs has an electron mobility of 8000 cm^2/V-s while the hole mobility is only 400 cm^2/V-s. Strain and confinement can split the heavy- and light-hole valence bands, resulting in a predicted lower effective mass and higher mobility. NRL has demonstrated this with $In_xGa_{1-x}Sb$ quantum wells clad by AlGaSb, and GaSb clad by $AlAs_ySb_{1-y}$. In both systems, hole mobilities as high as 1500 cm^2/V-s were achieved at room temperature (a world record for any III-V compound) and p-channel FETs were demonstrated. Atomic layer deposition (ALD) is being applied to deposit gate dielectrics on ABCS materials; n- and p-MOSFETS have been demonstrated.

More information can be found at:
www.nrl.navy.mil/estd/6870.



SEM image of antimonide-based HBT