Thin Channel InAs Quantum Well Device for Tera Hetz and Post CMOS applications

Edward Yi Chang, C. I. Kuo, H.T. Becker, Y.C. Lin, H. Dang

Department of Materials Science and Engineering and Department of Electronic Engineering

National Chiao Tung University, Hsinchu, Taiwan

InAs based devices with very high operating frequency and very low power consumption have emerged as the most potential devices for future THz and post CMOS applications. In this talk, 60nm InAs-channel HEMTs with a very thin channel, a thin InAlAs Barrier layer, and a very high gate stem structure were fabricated and evaluated for RF and low-power logic applications. High current density of 650 mA/mm was achieved with an extremely high transconductance of 2114 mS/mm at $V_{DS} = 0.5$ V, indicating that the InAs-channel HEMTs can be biased at a low supply voltage to reduce overall dc power consumption, while maintaining relatively high current density and $g_m$. The current gain cutoff frequency ($f_T$) and maximum oscillation frequency ($f_{max}$) of the device were extracted to be 710 GHz and 478 GHz at low $V_{DS}$ of 0.5 V, respectively. Impact ionization due to the low bandgap of the InAs material will also be investigated for optimum operation condition.

For the logic characteristics, a low calculated gate delay (CV/I) of 0.54 psec was also achieved at $V_{DS} = 0.5$ V for InAs quantum well devices. The Drain Induced Barrier Lowering and sub-threshold slope were calculated to be 200 mV/V and 115 mV/dec, respectively. Compared to advanced silicon device, the InAs FETs exhibited better RF performance with lower DC power consumption which indicates the great potential of the III-V based device for high-speed and low-voltage digital applications for post-CMOS applications.

The electrical properties of Al$_2$O$_3$/InAs MOS capacitors were also investigated for post CMOS application. After Sulfide and HCl wet chemical treatments in conjunction with trimethyl aluminium (TMA) treatment, the C-V characteristics of the capacitor show small dispersion in accumulation region ($< 0.75\%$/dec) and the interface trap density lies in the low $10^{11}$ eV$^{-1}$cm$^{-2}$ region, demonstrating excellent interface properties can be achieved for the Al$_2$O$_3$/InAs MOS capacitors with simple chemical treatments, which paves the foundation for InAs based devices for future post CMOS logic application.