中国科学院半导体研究所

黄昆半导体科学技术论坛

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Title: The Development of Low Noise Avalanche Photodiodes

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Abstract: There have been significant advancements in the performance of Avalanche Photodiodes (APDs) over the last 25 years. A critical requirement for the multiplication region in APDs is a significant disparity between the electron and hole impact ionization coefficients (α and β, respectively). Work done at Sheffield and elsewhere demonstrated that in submicron multiplication regions, the effects of 'dead-space' reduced the excess noise that was being measured even though α and β were similar. Next came some new III-V alloys like InAs where the narrow bandgap and conduction band structure gave single carrier multiplication (the eAPD) much like what is seen in HgCdTe. More recently the use of antimony (Sb)-based III-V semiconductor alloys appears to enable low excess noise characteristics. These alloys, grown lattice matched on InP or GaSb substrates, offer a wide band-gap energy (~1.5 eV), enabling high electric-field operation in a Separate Absorption and Multiplication region APD (SAM-APD) configuration. Sb-containing alloys exhibit a small β/α ratio (k), resulting in low excess avalanche noise and improved gain-bandwidth products. Initial studies on GaSb substrates demonstrated a remarkable k value of 0.015 for AlInAsSb p-i-n structures. In comparison, the best previous non-Sb containing III-V material, AlInAs on InP, has a k value an order of magnitude higher at 0.2-0.3. Work done in Sheffield on the ionization properties of GaAsBi alloys suggests that the presence of a large Group V atom tends to decrease the SO band in the valence band, and this might explain why we see a small β in Sb based alloys and hence low excess noise. This presentation reviews some of these major achievements in APDs over this period and the prospects for high-sensitivity APDs suitable for applications in telecommunications, imaging, and sensing.

Biography: John P.R.David (FIEEE, FIET) received his B.Eng. degree and the Ph.D. degree in Electronic Engineering from The University of Sheffield in 1979 and 1983, respectively. From 1982 to 2001, he was a Research Associate at The University of Sheffield, studying impact ionization coefficients and III-V materials characterization. From 2001 to 2002, he was a Senior Engineer with Bookham Technologies before returning to The University of Sheffield as a Senior Lecturer and is now a Professor. From 2002 to 2004, he was an IEEE LEOS (now Photonics Society) Distinguished Lecturer, giving presentations on the topic of "Low Noise Avalanche Photodiodes." He has published in excess of 350 journal articles and has a similar number of conference presentations in the areas of avalanche photodiodes, impact ionization, and III-material characterization.

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