From Bardeen, Brattain, and the Point Contact Transistor to Light Emitting Transistor Structures: A View of the Past and Future Possibilities

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Abstract:
The observation of electrical gain in a semiconductor device and the explanation of why it occurred is unquestionably one of the most significant technological achievements of the 20th Century. The point contact transistor, which through the physics of band bending at surfaces and at metal-semiconductor interfaces allowed a simple piece of n-type germanium to act as a p-n-p device, started the modern era of semiconductor-based electronics. Observing and explaining the transistor effect required the combined experimental genius of Walter Brattain and the theoretical insights of one of the greatest condensed matter physicists, John Bardeen. The initial production of point contact transistors, and the eventual shift to the junction transistor technology initiated by Shockley, were the first steps toward the modern electronics we see today. The history and applications of the transistor will be reviewed, starting from the early work on crystal rectifiers and modern physics that enabled both the art and science needed to create transistor technology. Key advances in transistor technology will be further discussed, with a focus on bipolar junction transistors (BJTs) and heterojunction bipolar transistors (HBTs). More recent implications of transistor action in materials having a direct-bandgap base region will also be reviewed, leading to transistor devices with both electronic and photonic functionality. The potential uses and benefits of these light-emitting transistors (LETs) and transistor lasers (TLs) will be covered. Finally, the transistor-injected quantum-cascade laser (TI-QCL) will be presented, along with its possible applications in mid-IR through THz photon generation and modulation. These capabilities could facilitate communications and sensing across a broad portion of the electromagnetic spectrum.

Biographical Sketch:
John Dallesasse is a Professor of Electrical and Computer Engineering and Associate Dean in the Grainger College of Engineering at the University of Illinois at Urbana-Champaign (UIUC), where he's been for over 11 years. He also has over 20 years of industry experience in technology development and executive management, having led technically diverse and geographically distributed engineering teams. Prior to joining UIUC he was the Chief Technology Officer, Vice President, and co-founder of Skorpios Technologies where he was responsible for developing innovative methods for heterogeneous integration of compound semiconductors with silicon. His technical contributions include, with Nick Holonyak, Jr., the discovery of III-V Oxidation, which has become an enabling process technology for the fabrication of Vertical-Cavity Surface-Emitting Lasers (VCSELs) for optical networking, 3D imaging, and LIDAR applications. His research group at UIUC works on novel methods for heterogeneous integration using epitaxial transfer which have been applied to the fabrication of VCSELs and other photonic devices on silicon, on mode control methods which have been used to provide record single-mode powers on conventional VCSEL structures, and on mid-IR emitters using quantum cascade structures within a transistor structure. John has over 100 publications and conference presentations, and 51 issued patents. He serves or has served as the Chair of the Steering Committee for the IEEE Journal of Lightwave Technology, the Chair of the Steering Committee for the IEEE Transactions on Semiconductor Manufacturing, and as the Vice President of Technical Committees for IEEE-EDS. He is a Fellow of the IEEE and Optica.