IEEE Western Australia Section

Joint Chapter ESP:
Electron Devices Society
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The concept of electrostatic doping and related devices

A Seminar of the IEEE WA joint EDS/SSCS/IPS Chapter

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Venue: **Billings Room 3.04, 3rd floor. Electrical & Electronic Engineering Building**
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This seminar is open to the public and admission is free to all IEEE members and non-members

Abstract:

The 'electrostatic doping', also defined as gate-induced charge, is a unique feature of nano-size structures such as FD-SOI, nanowires, nanotubes, and 2D materials. In an ultrathin device, a positive gate bias induces electron population that spreads in the entire body (volume inversion or accumulation). This effect is very different from the charge-sheet interface layer formed in bulk semiconductors or in thick SOI. The thinner the film, the more uniform the in-depth carrier distribution. The original undoped body suddenly behaves as an N-doped region. Changing the polarity of the gate bias turns the body into a P-type region.

The electrostatic doping can be contemplated as the last chance to form junctions and contacts in desperate technologies where ion implantation is not applicable; examples of CNT, 2D, and NW devices will be discussed. A less cynical view is to take advantage of the fascinating doping metamorphosis which offers unrivalled flexibility for conceiving novel and reconfigurable devices. For example, the band-modulation devices (FED, Z2-FET, Z3-FET) consist of successive N and P regions that are electrostatically doped to emulate a thyristor NPNP. An ultrathin extended drain MOSFET (LDMOSFET) with fully depleted drift region cannot drive current unless the virtual doping of the drain extension is tuned via a ground plane. The GDNMOS features 5 doped regions out of which two have versatile doping, adjustable for achieving good ESD protection. The operation of sharp-switching devices like tunneling FET (TFET), I-MOS and Electron-Hole Bilayer TFET also relies on electrostatic doping.

Another interesting device is the Hocus-Pocus diode which can be emulated in ultrathin, fully-depleted Silicon-On-Insulator (FD-SOI) films by appropriately biasing the front and back gates. Adjacent electron and hole populations form a virtual P-N junction. The current-voltage characteristics reveal similarities and major differences with those of conventional P-N diodes with ion-implanted doping. The lateral electric field from the anode combines with the gate-induced vertical field and leads to unusual two-dimensional 2D effects. A distinct merit of the virtual diode is the possibility to adjust the concentrations of electrostatic doping via the gates. The reverse current, forward current and depletion depth become gate-controlled. By modifying the type of electrostatic doping (N or P), the virtual diode can be reconfigured in 8 other devices: semi-virtual diodes, PIN diodes, tunneling field-effect transistors (TFETs) or band-modulation FET.

We will discuss in detail the device physics, architecture, and applications for the most promising devices with electrostatic doping.

Biography:

Professor Sorin Cristoloveanu received the PhD (1976) in Electronics and the French Doctorat ès-Sciences in Physics (1981) from Grenoble Polytechnic Institute, France. He is currently Director of Research CNRS. He also worked at JPL (Pasadena), Motorola (Phoenix), and the Universities of Maryland, Florida, Vanderbilt, Western Australia, and Kyungpook (World Class University project). He served as the director of the LPCS Laboratory and the Center for Advanced Projects in Microelectronics, initial seed of Minatec center. He authored more than 1,100 technical journal papers and communications at international conferences (including 160 invited contributions). He is the author or the editor of 28 books, and he has organized 25 international conferences. His expertise is in the area of the electrical characterization and modeling of semiconductor materials and devices, with special interest for silicon-on-insulator structures. He has supervised more than 90 PhD completions. With his students, he has received 13 Best Paper Awards, an Academy of Science Award (1995), and the Electronics Division Award of the Electrochemical Society (2002). He is a Fellow of IEEE, a Fellow of the Electrochemical Society, and Editor of Solid-State Electronics. He is the recipient of the IEEE Andy Grove award 2017.