UCF DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Fall 2016 Seminar Series

Two-Dimensional Materials (Graphene and Beyond) for Electronics - Opportunities and Challenges

WEDNESDAY September 28, 2016
10:00 AM – HEC 356

During the past decade, 2D (two-dimensional) materials have attracted enormous attention from various scientific communities ranging from chemists and physicists to material scientists and device engineers. The rise of the 2D materials began in 2004 with the pioneering work on graphene at Manchester University and Georgia Tech. Particularly the observed high carrier mobilities raised early expectations that graphene could be the perfect channel material for MOSFETs and supersede the conventional semiconductors. It soon became clear, however, that due its zero bandgap graphene is not suitable for MOSFET channels. Therefore, the prospects of graphene transistors are assessed rather pessimistic now. However, researchers have extended their work to 2D materials beyond graphene and the number of 2D materials under investigation is continuously rising. In part these materials possess sizeable bandgaps and therefore are considered to be useful for electronic applications. Indeed, experimental transistors with channels made of different 2D materials beyond graphene have been demonstrated. On the other hand, and in spite of the rapid progress in the field, there is still a controversial debate on the real prospects of 2D MOSFETs for future electronics.

In the lecture the most important classes of 2D materials are introduced and the potential of 2D transistors is assessed as realistically as possible. To this end, we compose a wish list of material properties needed for a good transistor channel and examine to what extent the 2D materials fulfill the criteria of the list. The state of the art of 2D transistors is reviewed and a balanced view of both the pros and cons of these devices is provided. Moreover, we compare their performance to that of competing conventional transistors, in particular Si MOSFETs and III-V HEMTs, and finally identify potential applications of 2D transistors in both the More Moore and More Than Moore domains of semiconductor electronics.

We will show that 2D channel materials with heavy carrier effective mass may enable MOSFET scaling beyond the limits of the Si MOSFET and extend the lifetime of Moore's Law in digital CMOS. Since digital CMOS covers around 70% of the overall chip market, this could be of huge importance for semiconductor industry. Moreover, 2D materials are bendable and stretchable and therefore show promise for the emerging field of flexible electronics.

Dr. Frank Schwierz

Technische Universitat, Ilmenau, Germany

Frank Schwierz received the Dr.-Ing. and Dr. habil. degrees from Technische Universität (TU) Ilmenau, Germany, in 1986 and 2003, respectively. Presently he serves as Privatdozent at TU Ilmenau and is Head of the RF & Nano Device Research Group. His research interests include semiconductor device physics, ultra-high-speed transistors, and novel device and material concepts for future transistor generations. At present he is particularly interested in two-dimensional electronic materials (graphene and beyond graphene).

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