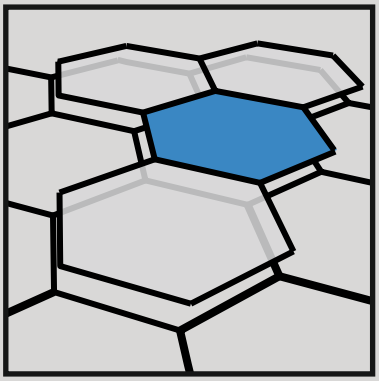

Aachen Graphene & 2D-Materials Center

Aachen-Graphene Flagship-Seminar

November 26, 2019
at the Physikzentrum Melaten
12:15 - 13:00h in 28A301

IEEE Distinguished Lecture

2D Electronics - Opportunities and Challenges

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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 work on graphene done at Manchester University and Georgia Tech. Particularly the observed high carrier mobilities raised early expectations that graphene could be a perfect electronic material. It soon became clear, however, that due its zero bandgap graphene is not suitable for most electronic devices, in particular transistors. On the other hand, researchers have extended their work to 2D materials beyond graphene and the number of 2D materials under investigation is continuously rising. Many of these materials possess sizeable bandgaps and therefore may be useful for transistors. Indeed, the progress of research on 2D transistors has been rapid and MOSFETs with semiconducting 2D channels have been reported by many groups. A recent achievement was the demonstration of a 1-nm gate MoS_2 MOSFET in 2016. Moreover, other types of 2D devices such 2D memristors, 2D sensors, and 2D devices optoelectronics are currently under investigation.

In the present 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, two key material properties – bandgap and mobility – are examined in detail and the mobility-bandgap tradeoff is discussed. The state of the art of 2D transistors is reviewed by summarizing relevant results of leading groups in the field and by comparing the performance of 2D transistors to that of competing conventional transistors. Based on these considerations, a balanced view of both the pros and cons of 2D transistors is provided and their potential in digital CMOS and in other domains of semiconductor electronics is discussed. It is shown that due to the rather conservative CMOS scaling scenarios described in the most recent ITRS and IRDS editions (compared to the more aggressive scenarios of previous ITRS editions), in the near-to-medium term it will be difficult for 2D materials to make inroads into mainstream CMOS. However, research on beyond-CMOS 2D devices has led to promising results. Exemplarily, the status and prospects of 2D sensors and 2D memristors is discussed.