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Optoelectronics with 2D semiconductors

THOMAS MUELLER, Vienna University of Technology

Two-dimensional (2D) atomic crystals, such as graphene and layered transition-metal dichalcogenides, are currently receiving a lot of attention for applications in electronics and optoelectronics. In this talk, I will review our research activities on electrically driven light emission, photovoltaic energy conversion and photodetection in 2D semiconductors. In particular, WSe2 monolayer p-n junctions formed by electrostatic doping using a pair of split gate electrodes, type-II heterojunctions based on MoS2/WSe2 and MoS2/phosphorene van der Waals stacks, 2D multi-junction solar cells, and 3D/2D semiconductor interfaces will be presented. Upon optical illumination, conversion of light into electrical energy occurs in these devices. If an electrical current is driven, efficient electroluminescence is obtained. I will present measurements of the electrical characteristics, the optical properties, and the gate voltage dependence of the device response. In the second part of my talk, I will discuss photoconductivity studies of MoS2 field-effect transistors. We identify photovoltaic and photoconductive effects, which both show strong photoconductive gain. A model will be presented that reproduces our experimental findings, such as the dependence on optical power and gate voltage. We envision that the efficient photon conversion and light emission, combined with the advantages of 2D semiconductors, such as flexibility, high mechanical stability and low costs of production, could lead to new optoelectronic technologies.