Electronic Materials – Synthesis, Processing, Device Fabrication

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Organic electronic devices such as light emitting diodes, field effect transistors and solar cells need conjugated molecules which are able to absorb and emit light, or are involved in the formation, transport, and annihilation of charges.

These active components can be small organic pi-systems or conjugated polymers. Organic chemistry has learned to control their relevant properties such as color or redox potentials by sophisticated molecular design, and some recent breakthroughs of “synthesizing electronic properties” will be shown. These examples are thin-film devices that require film formation from solution or the gas phase. Often, supramolecular order and morphology control are additional requirements upon such deposition. The interplay of synthesis and processing will be demonstrated for donor-acceptor polymers and organic chromophores.

While silicon seems to be the semiconductor of choice for the foreseeable future, problems associated with miniaturization of devices and printed circuits will demand alternatives. Here, we introduce disk-type polycyclic aromatic hydrocarbons (PAHs) and graphene nanoribbons (GNRs) as new families of carbon-based semiconductors. The former are small cutouts of the graphene lattice, the latter are a special case of conjugated polymers which allow the highly desired bandgap opening of graphenenes by geometric confinement.

As briefly introduced in the first talk, the fabrication of GNRs becomes possible in two ways: 1) by classical polymer synthesis in solution; or 2) after immobilization of monomers on surfaces and polymerization with in-situ monitoring by scanning probe microscopy. Precise engineering of band structures is achieved via controlling the lengths and aspect ratios of the ribbons. More importantly, the atomically precise formation of the peripheries (arm-chair, cove, zig-zag) leads to edge states and thus allows entry into spintronics. Examples of FETs including single-GNR devices will also be shown as well as the incorporation of 5- and 7-membered rings as a means of defect engineering. We then compare GNRs with conventional conjugated polymers whereby the former appear much more versatile in terms of possible applications and electronic structure control.

Klaus Müllen was director at the Max Planck Institute for Polymer Research. He now holds an emeritus position for continuation of his research there and is fellow of the Gutenberg Research College of Mainz University. His broad research interests range from new polymer-forming reactions, to the chemistry and physics of single molecules as well as graphenenes, dendrimers and biosynthetic hybrids. He published about 1,900 papers. He received the Max Planck Forschungspreis, Philip Morris Forschungspreis; Nozoe-Award; Science Award of the “Stiftverband”; Innovation Award of the State of North Rhine Westphalia; Nikolaus August Otto Award; Society of Polymer Science Japan International Award; Americal Chemical Society (ACS) Award in Polymer Chemistry; Tsungming Tu Award, Taiwan; BASF-Award for Organic Electronics; Franco-German Award of the Société Chimique de France; Adolf-von-Baeyer-Medal; Utz-Hellmuth-Felcht Award, SGL Group; China Nano Award; Carl Friedrich Gauß-Medal, van’t Hoff Award of the Royal Netherlands Academy of Sciences as well as the Hermann-Staudinger Award and the Award of the Academy of Sciences and Humanities in Hamburg. From 2008-09, he served as president of the German Chemical Society (GDCh). In 2013-14, he was president of the German Association for the Advancement of Science and Medicine. He is member of the American Academy of Arts & Sciences, North-Rhine-Westphalian Academy for Sciences and Art, National Academy Leopoldina, European Academy of Sciences, Braunschweigische Wissenschaftliche Gesellschaft and Academia Europaea. In 2010, he received an Advanced European Research Grant for his work on nanographenenes. He is associate editor of the Journal of the American Chemical Society.

Regents Professor Paul G. Gassman died in April 1993, at the age of 57. He was internationally know in the chemical community, and left behind a legacy of achievement. During his career, he served as mentor and adviser to 85 doctoral and master’s candidates as well as dozens of postdoctoral associates and undergraduate students. Numerous awards, honors, and honorary degrees were bestowed in recognition of his contributions to research and his service to the scientific, professional, and university communities. Some of these awards include election to the National Academy of Sciences (1989) and to the American Academy of Arts and Sciences (1992); the James Flack Norris Award in Physical Organic Chemistry (1985); Arthur C. Cope Scholar Award (1986); and the National Catalyst Award of the Chemical Manufacturers Association (1990). He served as president of the American Chemical Society in 1990. He was co-chair of the organizing committees of the National Organic Symposium (1991) and the National Conferences on Undergraduate Research meeting (1992), on the University of Minnesota campus. It was his wish that a lectureship be established to bring distinguished organic chemists to the Department of Chemistry. We are proud to present this lecture series in his honor.