Course title: Materials and material systems for acoustic wave devices

Course Description: Starting from a survey about the modern types of acoustic wave devices (SAW and BAW), their construction and functional peculiarities, the related material requirements are considered. According to the primary operating principle piezoelectric anisotropic materials are brought into focus at first. The physical basics of elastic, dielectric, and piezoelectric behaviour are exposed including suitable mathematical description of properties. Then the most relevant parameters of SAW and BAW (phase and group velocity, coupling factor, temperature coefficients, reflection coefficient, propagation loss) and their physical origin are considered enabling one to evaluate the suitability of given material for a specific application case. Subsequently, the established single crystalline materials for SAW and BAW devices like quartz, lithium niobate, lithium tantalate, langasite with all facets of orientational dependence of properties, acoustic wave type, and application peculiarity are discussed and compared. As well also new crystalline materials that are under development initiated by specific application challenges (operation at high temperatures, extreme high frequencies) are considered. A changeover follows from single materials to material systems formed by thin films on a substrate in the simplest case. Various material combinations film/substrate come into question corresponding to the aimed objective (e.g. high speed SAW, temperature compensation, chemical passivation). Again following the main device function, piezoelectric thin films as alternative material solution for both SAW and BAW devices (such as FBAR, SMR, HBAR) instead of crystal plates are considered at the beginning. The requirements, fabrication techniques and properties of SiO_2 layers widely used for different reasons is discussed subsequently. Afterwards material systems allowing the existence and electrical generation of boundary waves (or interface waves) are discussed. At this point wafer bonding as a significant assembling route for material systems of acoustic wave devices is treated. Next part is devoted to aging of device parameters being a distinct feature of material systems because of inherent diversified responses of system components to external impact. Because of various influences on device performance the electrode material is included in the course. Discussed are viewpoints of function (SAW reflection coefficient) as well as durability (acoustomigration) and the relation to geometry and fabrication technique (Damascene technique, buried electrodes).

Manfred Weihnacht was born in Leipzig, Germany. He received his diploma, Ph.D., and Dr. habil. degree in physics in 1963, 1971, and in 1990, respectively, from the Dresden University of Technology. He worked as a head of laboratory from 1963 to 1975 on superconducting thin films and tunnelling structures for applications in low temperature electronics in industrial research (Kombinat Robotron Dresden) and at the University of Jena, Germany. In 1975 he joined the Institute of Solid State and Materials Research (IFW) in Dresden. He was assigned to establish a research group and start work on piezoelectric materials and surface acoustic waves and its application in devices. His activities covered the fundamentals of crystal acoustics, SAW device modelling, measurement techniques, and the development of new materials, spanning all kinds of constitution from thin and thick films, ceramics to single crystals. The work of the group under his direction has a long history of worldwide collaboration on SAW devices and related materials research with partners especially in industry. In current time, innovations of combined use of microacoustics and microfluidics for biology and medicine are in special focus of his joint work with a young scientists group in IFW Dresden. Since 1995 he has published more than 60 journal papers and 80 conference contributions. He helds 23 patents. Dr. Weihnacht is member of the German Physical Society and Senior Member of IEEE. He was an Elected Member 2006-2008 of the Administrative Committee of the UFFC Society of IEEE.