Enabling technologies, technological waves and future perspectives of vacuum electronics

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Abstract:
Vacuum electronics (VE) have been one of the motors of industrial growth in the last 130 years. The development of VE concepts has been pushed by several technological waves/cycles, starting with incandescent lamps, continuing with the radio tube era and then followed by the cathode ray tubes (CRTs) [1,2]. Before and during these cycles also the enabling technologies for VE, especially vacuum technology and cathode technology, have been developed and have been improved tremendously over time. A general prerequisite of course is the availability of electric power: the historical advances in this field are also discussed. Despite the decay of the first three waves, vacuum electronics is still alive in the form of microwave tubes, X-ray tubes, electron beam devices for materials processing and analysis, ion propulsion systems, particle accelerators and several other applications. In the case of microwave tubes their specific advantages in the high power/high frequency domain over solid state devices (SSD) are discussed [2,3]. The disadvantages of SSDs in this respect are mainly due to high power losses by electron collisions in the solid, lower voltage breakdown limits and lower tolerable operating temperatures [3]. Hence VE advantages could open new perspectives for future applications in IC design. In this talk the different technological waves are described and then the progress of the two main enabling technologies is elucidated, monitored by decreasing vacuum base pressure and increasing cathode emission capabilities both for thermionic and cold cathodes. Finally future perspectives for VE are given, including standard VE technology and vacuum nano electronics.

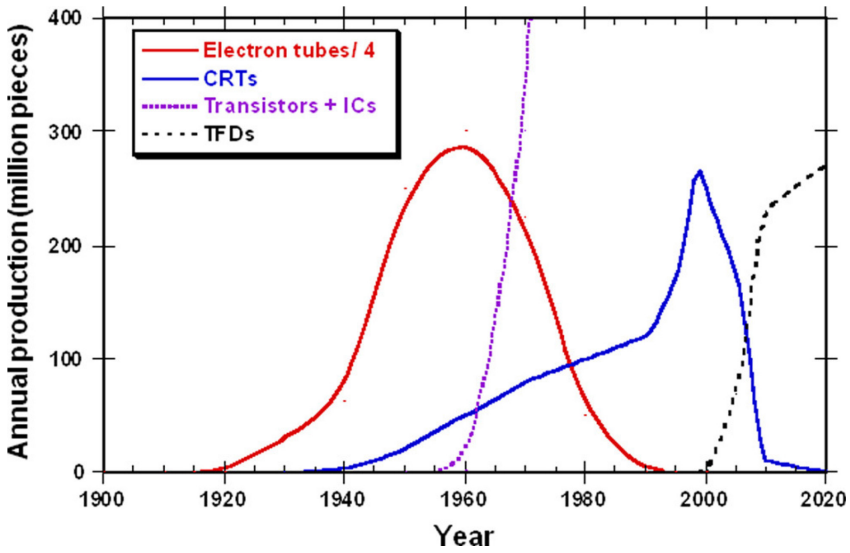

Fig. 1: Historical trends/ technological waves in vacuum electronics and neighboring fields according to [2].

References:

[1] G. Gaertner, H.W.P. Koops: „Vacuum Electron Sources and their Materials and Technologies“, chapter 10 of „Vacuum Electronics, Components and Devices”, Ed. J. Eichmeier, M. Thumm, Springer 2008
[2] G. Gaertner: „Historical development and future trends of vacuum electronics“, J. Vac. Sci. Technol. B, Vol. 30, No. 6, 060801 (2012)
[3] Editors: R.J. Barker, J. H. Booske, N. C. Luhmann, and G. S. Nusinovich: „Modern Microwave and Millimeter-Wave Power Electronics“, Wiley-IEEE, New York, 2005