The historical development of the enabling technologies for vacuum electronics and their impact on its progress

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Abstract:
Vacuum electronics have been one of the motors of the progress in physics and of industrial growth in the last two centuries. The historical rise of vacuum electronics (=VE) is directly linked to the availability of electrical power and to vacuum technology, but in later stages also surface science and solid state technologies contribute to its progress. The major prerequisite for vacuum electronics is the availability of electric power generators and, later on, of a distributing grid for power supplies. Hence, the advances in this field are first addressed. They happened some decades before the rise of vacuum electronics [1,2,3] started. We find a similar development (limiting) growth curve as in other fields of technology. The second basic condition for the rise of vacuum electronics is the availability of vacuum and hence vacuum technology. The ultimate vacuum reached, as a figure of merit, was also improved as a function of time from 1850 on to the UHV and XHV levels today. Vacuum technology and vacuum electronics also enabled the development of surface science and improved materials characterization, which had again an impact on cathode development. In the end, also the introduction of the transistor and of solid state technologies not only started a new technological wave, but also triggered the introduction of new field emitting cathode types (e.g. Spindt emitters) and helped to improve existing cathode types e.g. by application of thin film deposition. I will link the rise of different subsequent technologies with the different technological waves or cycles, such as the incandescent lamp era, the radio tube era or the CRT era, and finally, also to cathode development and improvement over time. 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. The advantages of VE either lie in the high power/high frequency domain (microwave tubes and terahertz devices) or in high brightness electron beams. Advanced application demands also trigger further improvement of cathode performance and technology.

References:

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