Si tip field emission electron source for application in ionisation vacuum gauges

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ABSTRACT

Compact Si tip field emission (FE) electron sources can be used for a wide range of applications in sensor technologies [1]. In ionisation vacuum gauges free electrons emitted from an electron source are used to ionize the residual gas molecules inside the vacuum chamber. This ion current is used as a measure for the pressure. This ionization process is most efficient for electrons with energies around ~ 150 eV. In conventional ionisation vacuum gauges the electrons are emitted from a heated filament. However, there is the risk of a burn-through in the case of a rapid pressure increase and a limited life time. The advantage of a Si tip field emission electron source compared to hot filament emitter is a lower power consumption. Also a faster response time is possible if the electron source needs to be switched off for protection in the case of an unintended pressure increase inside the chamber. Compared to other FE materials p-type Si emitters show very stable emission currents and a good emission uniformity [2]. In order to obtain sufficiently high electron currents an operation voltage up to 1 kV or more is required when using conventional Si tip arrays. By placing gate electrodes in close distance to the individual tip emitters it is possible to reduce the operation voltage considerably in order to obtain the preferred electron energies. We realized arrays of 16 and 100 gated p-type Si tips. The tips are surrounded by the gate electrode at a distance of approximately 2 µm to the apex of the tip [3]. The electron source was pre-characterized in a setup consisting of the gated Si tip cathode, a mica spacer, and a fine-meshed extraction grid. A stable emission current in continuous mode operation was observed, even when the pressure was increased up to 10^{-4} mbar. In the next step the electron source was used to replace the filament of a commercial Bayard-Alpert vacuum gauge (Leybold IE 414). The FE cathode was set to a bias voltage of 25 V, the gate to 125 V, the extraction grid electrode to 400 V, and the anode to 600 V. The potential of the ion collector was set to 0 V. A pressure sweep from $\approx 10^{-7}$ mbar to 10^{-4} mbar was performed and the total emission current, the anode current, as well as the ion current were recorded. This measurement revealed a sensitivity of the ionisation vacuum gauge of about 25 $mbar^{-1}$.

References

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