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Recent Progress of Cold Cathodes: Volcano-structured Field Emitters and GOS Tunneling Cathodes

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Vacuum devices are dominant in high power and high frequency. Though thermal cathodes are widely used in vacuum devices, if the thermal cathodes are replaced with cold cathodes, more superior devices are expected. The conventional cold cathodes with an electron extraction gate is field emitters (FEs). The FEs, however, have two big problems such as current fluctuation and beam divergence. The current fluctuation is suppressed when the FE is operated in ultra-high vacuum or connected in series to a constant current source such as a field effect transistor [1, 2]. For the beam divergence, though the double–gated FE with both an electron extraction gate and a focus gate was proposed, the electron emission current was significantly reduced when the electron beam was focused. Recently, we have developed the volcano-structured double-gated field emitter (VDG-FE) [3, 4]. The VDG-FE can focus electron beam without decrease of the emission current. By using the VDG-FE, we are developing the compact image pickup tube which is applicable to a radiation tolerant image sensor [5].

As the second topic, I will talk about fabrication of graphene and its application to planar Graphene-Oxide-Si (GOS) tunneling cathodes with an extremely high electron emission efficiency. The Metal-Oxide-Si (MOS) tunneling cathode is a fine cold cathode, because it has fluctuation free emission current, produces uniform emission from the whole emitter area, and has a highly directional electron beam. Furthermore, the electron emission is almost independent of the ambient gas pressure. However, MOS cathodes have very low electron emission efficiency less than 1% [6]. We synthesized graphene by low pressure chemical vapor deposition. We have developed GOS tunneling cathodes with an extremely high electron emission efficiency larger than 20% by replacing the poly Si gate electrode of MOS cathodes with a graphene electrode [7].

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