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High Quantum Efficiency Photocathode Using Surface Plasmon Resonance

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Super-radiant Smith-Purcell radiation using a pre-bunched electron beam is a very attractive terahertz light source because it does not require an extremely high initial current density. In order to modulate an electron beam in terahertz region, the metal photocathode excited by deep ultraviolet (DUV) laser is a promising candidate because of its fast response time less than 10^{-12} sec. However, the photocathode has low quantum efficiency (QE) of the order of 10^{-4}. This is because reflectance at the metal surface is relatively high and electrons excited inside the metal by laser light suffers electron-electron scattering before escaping into vacuum. To overcome such problems, we have proposed the photocathode using surface plasmon resonance and investigated the emission properties. The surface plasmon resonance reduces light reflection to zero because all incident photons are absorbed by surface plasmon at the resonance angle. Consequently, all the incident photon energy is transferred to surface plasmon. The electrons excited in surface plasmon do not need to travel inside the metal before escaping into vacuum, because the evanescent wave couples with surface plasmon just at the interface between vacuum and the metal film. To drastically improve QE, it is quite import that the direction of the momentum of plasmon have to agree with the direction of e emitting electrons. We have achieved the QE 10^3 times larger than the previous value.