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Cathodoluminescence Study of Surface Plasmon Polariton in Plasmonic Cavities

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1. Introduction

High resolution cathodoluminescence (CL) technique combined with a scanning transmission electron microscope (STEM) is useful for investigating physical property of a nano-region by detecting an emitted light due to interaction between high energy electrons and materials. Light emission induced by surface plasmons in metal surface structures has been studied by the STEM-CL technique with a high spatial resolution of nanometer scale [1-3]. Resolution of STEM-CL is mainly limited by a probe size of the electron beam, and is typically in the order of 1 nm.

2. Results

In the present study we investigate the properties of surface plasmon polariton in plasmonic cavities on metal surfaces by using a CL detection system equipped with a 200keV-STEM. Surface plasmon polariton (SPP) on metal surfaces can be excited by high energy electrons, and is converted to photons when propagating in the cavities. Light emitted from a specimen in the STEM is collected by a parabolic mirror to change to a parallel light, and is detected by a CCD detector. Shape of cavity was fabricated on semiconductor substrates by electron beam lithography and silver was thermally deposited on it. Several types of cavity structures were made, such as a single groove, a pair of grooves or terraces and those sandwiched by periodic structures (plasmonic crystals). Fiures 1 (a)-(e) show angle resolved spectral (ARS) patterns of the emissions from the cavities, which show how the emission change with increasing number of pairs N. The emission intensity at 2 eV is seen to increase with N. The standing SPP waves in the cavities are illustrated in Fig. 1(f) and (g) for the N=1 and 2 cavities. In the case of N=1 the SPP wave tends to have an anti-nodes at the outer steps. It is noted that the cavity energy does not change with increasing number N. The standing SPP waves in the cavities were directly visualized by the electron beam scan spectral imaging technique. Similar observation was also applied to 2 dimensional cavities surrounded by a plasmonic crystal wit a hexagonal lattice.

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References

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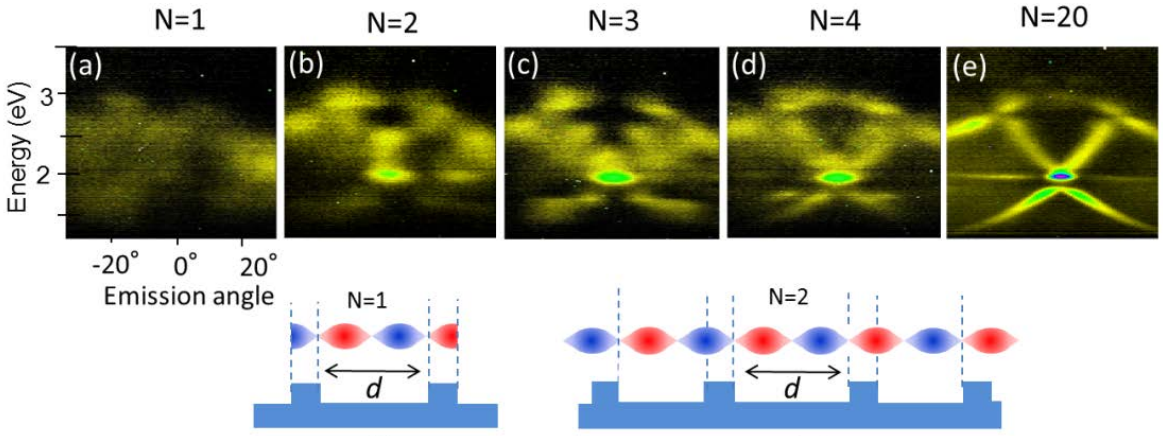

Fig.1 (a)-(e) Angle-resolved spectral (ARS) patterns from 1D-cavities composed of various numbers of terrace pairs, (f) and (g) schematic illustrations of standing SPP waves in the N=1 and 2 cavities.