Electromagnetic resonance through narrow slots in a transmission cavity in a thick conducting screens

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Since H. A. Bethe reported his work [1] on the electromagnetic coupling through a small hole in the conducting plane, it has been well-known that the transmitted power P_t through the small aperture in an infinite conducting plane is expressed by multiplication of the incident power density $P_{inc}[watts/m^2]$ and the transmission cross section TCS T$[m^2]$ which scaled as $(D/\lambda)^4 \cdot D^2$ for the hole diameter *D* much smaller than the wavelength λ. So the transmitted power through the small aperture becomes very small as *D* decreases. Recently lots of researches have been done with a view of enhancing transmission efficiency of small(subwavelength) aperture for the applications such as optical compact data storage, nanolithography, and nano-microscopy. As a result it has been found that the transmission efficiency can be significantly enhanced by reforming the aperture shape as in the circular ridged aperture [2] or by employing a small coupling aperture-to-cavity-to aperture system, i.e., a transmission resonant cavity system in a thick conducting screen. To distinguish between the two kinds of structures, we call the former and the latter TRA(Transmission resonant aperture) and TRC(Transmission resonant cavity) structure respectively. It is interesting to note also that TCS T for both the above two structures can be increased to the maximum value of $T_{max} = 3\lambda^2/4\pi[m^2]$ for the TRA case and for the TRC case that input(incident side) and output coupling hole are the same to each other as a small hole. This means that incident power on the much larger area than actual aperture area is funneled into the physical aperture and transmitted through TRA/TRC structure and radiated into the opposite half space to incident side under the transmission resonance where the transmitted power P_t becomes maximum. In this article, we focus our interest to investigating the unsymmetrical transmission resonance cavity(TRC) case where input coupling aperture and output coupling aperture are different from each other. In particular we deal with the case that the input/output coupling holes are of narrow slot type for the convenience of analysis.

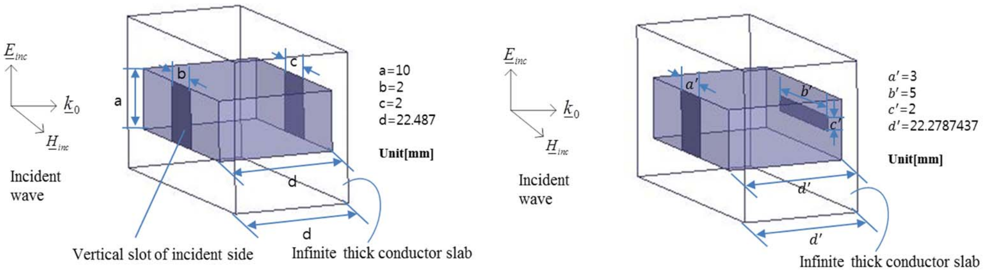

Fig 1. Symmetrical (a) and unsymmetrical (b) transmission cavity structures

For this purpose we investigate the transmission cross section as a measure of transmission efficiency through the transmission resonant cavity structure as shown in the Figs. 1 (a) and (b) which illustrate symmetrical and unsymmetrical transmission resonant structures respectively. Here the electromagnetic plane wave is assumed vertically polarized. Through this work, it is observed that the TCS of the transmission resonant cavity remains almost the same, if the same input(incident) side aperture shape is kept unchanged as in Fig. 1, even though the output aperture shape is changed. So the almost the same TCS curves are observed for both cases of Figs. 1 (a) and (b). Next we investigate the TCS characteristics for the case that input and output coupling slots in Fig. 1 (b) are interchanged. In this case, TCS curve is seen significantly to change. From this it can be said that the TCS characteristics is mainly determined by the gain G of the incident side coupling aperture structure as $\mathrm{T} = \frac{2G\lambda^2}{4\pi}[m^2]$, which is compatible to the previous observation in [3].

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