THE DISTINCTION BETWEEN ZENNECK WAVES AND SURFACE PLASMON POLARITONS

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In this work, the distinction between Zenneck waves and surface plasmon polaritons is illustrated. The main contribution of Zenneck was the development of a specific type of solution of Maxwell's equations in a three dimensional space. This solution is an inhomogeneous type of plane wave and generally occurs at a Brewster zero. Surface plasmons are characterized by a pole of the reflection coefficient. The Zenneck waves are produced at the zero of the reflection coefficient of an incident TM wave on an air-dielectric interface whereas the surface plasmons are produced when the reflection coefficient is infinite and the conditions are right for this phenomenon to occur.

The zero of the reflection coefficient illustrates the Brewster's phenomenon and the pole of the reflection coefficient illustrates the presence of a surface plasmon. At the zero of the reflection coefficient, the resultant fields are only the incident field in one medium and the transmitted field in the second medium. The pole in the reflection coefficient on the other hand generates a reflected field and a transmitted field without an incident field as the reflection coefficient becomes infinity. The surface waves cannot be generated using a transverse electromagnetic wave as in this case there is no incident wave, but rather through an evanescent wave as an evanescent wave behaves as a quasiparticle and can tunnel through the medium. Both the Zenneck wave and a surface plasmon decay exponentially as one moves away from the planar interface and these evanescent waves propagate with a low loss along the radial direction. In addition, it is well known that the Brewster's angle is practically independent of frequency (the losses have a second order effect on the Brewster phenomenon) whereas the surface plasmon phenomenon is highly dependent on frequency. So for a Zenneck wave, the transverse evanescent nature of the fields are essentially independent of frequency whereas for a surface plasmon, the fields are bunched closer to the surface as the frequency increases. Also for the surface wave to occur, typically the dielectric constants of the two medium should be of opposite sign and with the dielectric medium having a small loss, compared to the real part. A negative value for the dielectric constant with a small imaginary part occurs in metals generally in the petahertz regions.

We will show that for propagation over urban ground, the surface plasmon phenomenon is nonexistent since the reflected field strength from a dipole radiating over an imperfect ground reflects the strong influence of the Brewster angle which is due to a zero of the reflection coefficient. Also, the reflected field strength does not vary as a function of frequency. The reflected field is a Zenneck type of a radiating wave strongly influenced by the Brewster zero of the reflection coefficient.