(4layer stack)

Here the system is developed further by the inclusion of a Hyperbolic Metamaterial (HMM). These are of interest due to their unusual optical properties. There are many different types of HMM structures, the two that are looked at here are the Layered metal-dielectric structures (sheets) and metal nanorod arrays in dielectric (nanowires) as shown in figure\_\_ .

recently

Metamaterials are materials which have properties beyond those seen naturally in nature our system already contains one in the form of the NP layer. However, here we are looking at hyperbolic metamaterials specifically materials with either thin film or nanowire geometry. to determine there optical responses we utilised the effective medium theory (EMT) . This approximation has one issue however and that is that it neglects occurrences of epsilon-near-zero (ENZ) however it is able to capture the epsilon-Near-Zero-and-Pole (ENZP) conditions which are of interest.

there are 4 dispersion different relations for HMM the one that is seen is determined by the effective dielectric constants

1. effective anisotropic dielectric: and
2. type I (behaves as a metal in the bulk and a dielectric in the plane): and
3. type II (behaves as a dielectric in the bulk and a metal in the plane): and
4. effective anisotropic metal: and

Brewster angle can be used to determine the type of the HMM is by one method that can be used to determine the type, as type I exhibit the pseudo-Brewster’s angle (p-polarised light is completely transmitted) however in type II this is absent due to it exhibiting mainly metallic characteristics

nw model is 500nm thick and sheets at 50% is 40 sheets at 8nm