corrugated layers absorb even more light, both by supporting high-k waves and by containing random cavities for them, where these bulk waves can oscillate and then be absorbed.

We should emphasize that no matter how random the metamaterial is the first continuous layers (counting from the flat substrate) always possess hyperbolic dispersion, while the outermost layers may or may not be "hyperbolic". Therefore it may happen that it is no longer possible to introduce meaningful effective parameters applicable to the whole metamaterial.

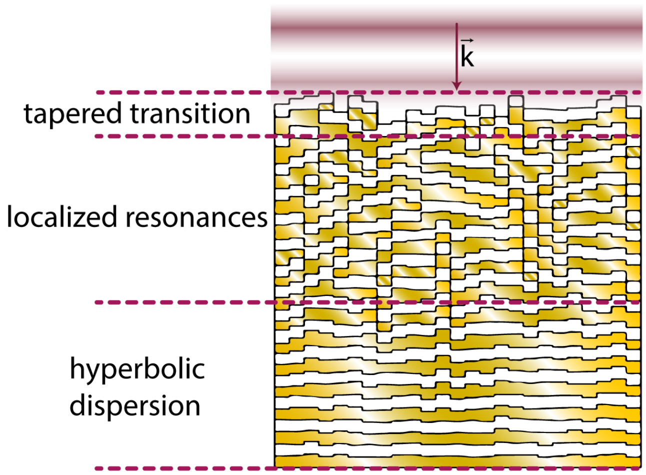

Fig. 6. The random HMM is very complex in a general case and various physical mechanisms can contribute to light absorption: reflection cancellation due to tapered air-HMM transition, localized plasmonic resonances and coupling to the high-k waves in the HMM.

One should keep in mind that the numerical model of a random hyperbolic metamaterial studied here is relevant for fabrication but still relatively simple. Obviously, in real fabrication we obtain not only longitudinal (thickness) variation, but also random variation of lateral particles sizes. Moreover, chemical composition of the constituents may vary randomly, too. Interesting effects can be observed in such complex system as random HMM, for example, Anderson localization of high-k waves.

Even such a simple model, however, shows us important indications. First of all, we confirm that roughness increases absorbance, shorter waves feeling the roughness stronger than longer waves. Second, smaller lateral roughness size results in larger absorbance, which is a counterintuitive but specific feature of HMMs where smaller rough features can excite larger-k waves. Third, and perhaps most importantly, not only the top rough layer but also the underlying rough layers play an important role in absorbance. The entire system is interesting and complex, as it combines several distinct absorption mechanisms together (Fig. 6).

The first conclusion that one can make is that absorbance in HMMs is very sensitive to the layers roughness and even small roughness (δ = 10% corresponds to thickness variation ± 5%) can increase absorbance by 2 times.

The second, much more optimistic, conclusion is that one should not put much effort into optimizing the fabrication to obtain ultra-smooth metal and dielectric layers for the HMM to act as an absorber. Naturally occurring disorder actually helps, so contrary to the common belief we can state that rough metal and dielectric layers, such as those that occur during conventional deposition techniques, make an even better hyperbolic metamaterial absorber.

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