Study of terahertz extraordinary transmission resonances depending on polarization.

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The topics of metamaterials [1,2] and extraordinary transmission [3] have attracted a lot of attention in the last years due to the intriguing properties associated to them. On the one hand, metamaterials have been a source of continuous development of new ideas and devices, as many well-established theories in electromagnetism were revisited with a different perspective. As a matter of fact, fascinating concepts such as negative refraction, perfect lensing and even invisibility were proposed after metamaterials. On the other hand, extraordinary transmission is mainly linked with plasmonics [4] which is a hot topic in today electromagnetism. It consists in high transmittance peaks arising in the cut-off region of subwavelength hole arrays. As mentioned, in its optical version, it is explained through surface plasmon polaritons [5]. However, its existence in other frequency ranges such as millimetre-waves where metals do not support plasmons showed that leaky waves [6], i.e. a kind of complex waves that can exist in periodic structures, are responsible for the high transmittance.

A very important result we achieved in the past, is the possibility to have left-handed propagation by stacking hole arrays [7]. Thus, metamaterials and extraordinary transmission structures are closely linked with a very simple arrangement. Moreover, this result can be easily downscaled to other frequencies such as terahertz, infrared or visible, since extraordinary transmission has been found also in those regimes.

From the knowledge obtained with the systematic experiments performed in millimetre-waves, we were able to miniaturize the structures of extraordinary transmission and get high transmission even with reduced spot illumination (illumination in the Fresnel zone of the incident gaussian beam) [8]. This result opened the door to extraordinary transmission structures working in the terahertz range [9]. The main modifications done to design miniaturized samples is (i) using a rectangular cell and (ii) loading the wafers with dielectric. In our terahertz experiments, the dielectric was polypropylene whose performance is highly satisfactory. This aspect is very important since it is cheap and easily available due to mass industrial production for the needs of the goods packaging sphere.

Apart from those technical details, we found an unexpected resonance below cut-off for the "wrong" polarization, and we termed it as anomalous extraordinary transmission.

In this presentation, we will focus on our developments in the terahertz range and will give some physical insight about the origin of anomalous extraordinary transmission. Novel spatial filters and metamaterial devices

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Figures:

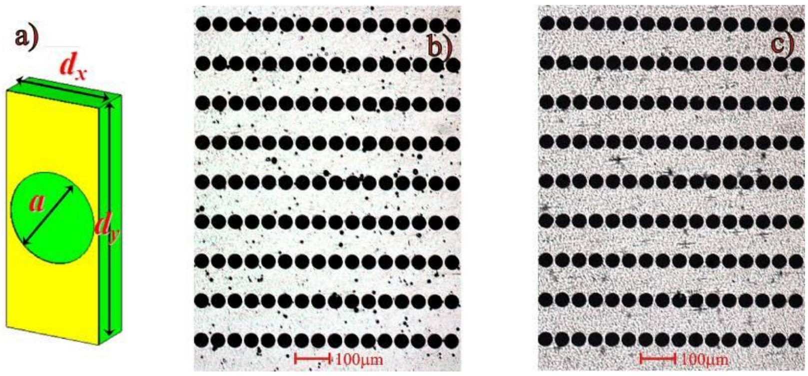

Fig. 1. Unit cell schematic (a) and photographs of the terahertz extraordinary transmission prototypes (b) and (c).

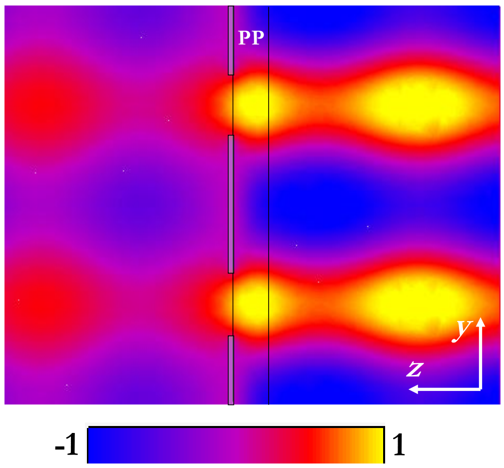

Fig. 2. Cross-sectional view of the electric field at the anomalous extraordinary transmission resonance.