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Implementation of THz Fabry–Perot Cavity Leaky-Wave Antennas based on Fishnet Metasurfaces

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Fabry–Perot cavity leaky-wave antennas (FPC-LWAs) are a class of leaky-wave antennas [1] that can be realized by covering a half-wavelength grounded dielectric slab with a partially-reflecting screen (PRS) that allows for radiating either a pencil beam at broadside, or a conical beam. The higher the reflectivity of the PRS, the higher the directivity of the beam, at the expense of a more resonant narrow-band character. Thanks to their simplicity, low-cost, low-profile, and attractive radiating features, these antenna technologies became widespread at microwave frequencies, where they can easily be fed through dipole-like sources such as print dipoles or resonant patches. Conversely, at terahertz (THz) frequencies, although original FPC-LWA designs based on graphene and showing tunable properties have recently been proposed (see, e.g., [2]), experimental validations are still lacking.

However, the issues arising from both graphene fabrication and THz technology still hinder the experimental realization of such devices [2]. For this purpose, FPC-LWA configurations working around 1 THz have been proposed in [3], showing no reconfigurable properties but a more amenable fabrication process. Interestingly, the analysis in [3] revealed that, among the various kinds of PRS that can be synthesized for realizing a THz FPC-LWA, those based on a fishnet-like unit-cell have several advantages when compared to the more conventional patch-like and strip-grating layouts [4].

In this work, we first review the properties of fishnet-like unit-cells to motivate their choice for the synthesis of a PRS to be used in a THz FPC-LWA. Then, we discuss an original FPC-LWA design working around 3 THz. Indeed, around this frequency it is possible to efficiently couple an FPC-LWA with the resonant modes of a step well quantum cascade laser (QCL) [5]. Specifically, the peak locations of the step-well modes and their full-width half-maximum drive the design of three different FPC-LWA layouts exhibiting operating frequencies and fractional bandwidths centered around the resonant frequencies of the QCL step-well modes. The radiating properties of the proposed devices are evaluated through accurate numerical simulations. Finally, we discuss a possible application of the proposed THz FPC-LWAs for efficiently and directly coupling energy to a THz bolometer as an alternative to more conventional antenna-coupled architectures based on log-spiral antennas (see, e.g., [6]).

References

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