Systematic design of perfect metasurface absorbers for ink-printing technology

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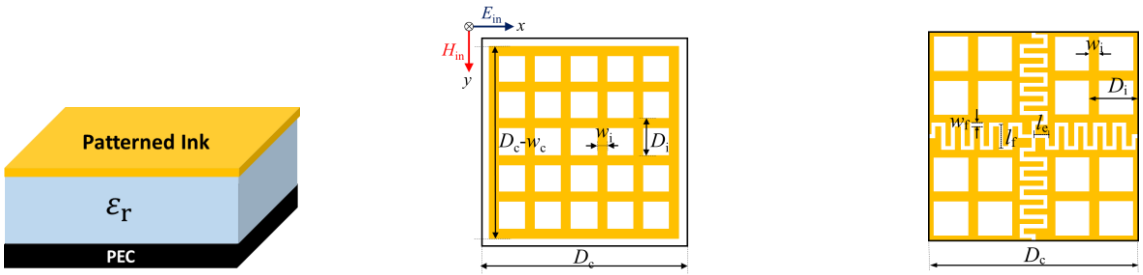
The suitability of ink-printing technologies for defining conductive patterns on a substrate can be used for massive and low-cost manufacturing of electromagnetic metasurfaces. In the last decade, large efforts have been carried out in improving the conductivity of ink materials for the design of antennas and transistors where highly conductive films are required. However, the existence of losses is necessary in the design of absorbers, making these technologies perfect candidates for metasurface absorbers. From the perspective of circuit models, the design principle of electromagnetic absorbers is in fact an impedance matching problem between the structure and the surrounding environment. For the sandwiched structure [see Fig. 1(a)], the value of the grid impedance of the top pattern which is needed to match the input impedance to the characteristic impedance of free space is uniquely determined by the substrate properties. For an ink layer with a given sheet resistivity, patterning it into the required impedance sheet is always a difficult task since both the grid resistance and reactance change when structuring the resistive sheet.

Here, we present a systematic method for tailoring the grid impedance of periodic patterns with independent control of their grid resistance and reactance. In this method, the grid resistance can be adjusted by introducing dense periodic slots along the current flow direction, as shown in Fig. 1(b). The grid resistance increases with widening the slot width, without affecting the grid reactance. On the other hand, the grid reactance can also be tuned by enlarging the period of the patch array while the grid resistance remains unchanged. Accurate analytical formulas for the proposed structure are derived and numerically verified. This allows fast prediction of the absorber performance instead of heavy simulation duty. Alternatively, by introducing meandered slots between the adjacent patches [see Fig. 1(c)], the grid reactance can also be effectively tuned in a large scale without changing the unit size. This method allows a flexible adaption for inks with different resistivities, as well as different substrates provided by the industry. It also allows us to synthesis absorbers operating at different frequencies with a prescribed sheet resistivity of ink.



(a) (b) (c)

Fig. 1. (a) The structure of the absorber. (b) Independent control of grid resistance. (c) Independent control of grid reactance (with meandered slot). The yellow color represents for ink layer.

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