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Transparent Conductive Nanowire Antennas

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Interests in developing optically transparent antennas with effectiveness in both optical clarity and radiation efficiency have been continuously growing. The reason is clear, because such an antenna can be seamlessly integrated or hidden into windows, displays, panels, etc. to enhance communication capacity without impacting any visual clarity or aesthetic appeal. Potential implementations of these antennas spans from vehicle-to-everything to indoor replays for 6G. Therefore how to improve the efficiency of these antennas to a practical value and how to reduce the cost of production become two urgent issues to resolve in order to realize all the exciting future applications.

There are two approaches to achieve optical transparencies, namely meshing a conductor and using an optically transparent conductor. The paper focus on antennas designed from conductive nanowire film, a type of transparent conductor that has the advantage of reduced cost, faster development cycle, and easier deposition methods, compared to more traditional transparent conductors such as indium tin oxide (ITO) and indium zinc tin oxide (IZTO). While the production of transparent oxides such as ITO is well developed, the material preparation often includes special facility such as a clean room and the conductivity of the transparent coating can be affected by factors such as processing temperature. This in turn, limits the material where the coating can be deposited. For example, when an application calls for a flexible substrate such as polyethylene terephthalate (PET), as the substrate may not withstand the temperature required by the ITO deposition, one has to reduce the temperature, which then cause a decrease in the electric conductivity of the ITO and it may no longer be suitable for antenna designs. Silver or Copper Nanowires, denotated as AgNW and CuNW respectively, on the other hand, requires much easier production process. CuNW, in particular, is much cheaper to produce, not only because the cost of Cu is lower than Ag, but also because the solvent used in preparing the nanowire is water. In addition, AgNW or CuNW can be deposited to various substrates (glass, plexiglass, PET) with inkjet printing, screen printing, or as easy as spray painting methods.

One of the challenges in antennas designed from transparent conductors is the low efficiency. This is essentially because the conductive films/coatings are extremely thin (often in the order of 10^{-1} 10^{-2} of the microwave skin depth at X band) and therefore have a high loss resistance. A patch antenna designed from transparent conductor has been shown to have very low gain such as 0 dB or less. This is accentuated if both patch and the ground are required to be visually clear.

This paper summarizes our latest development in efficiency-improved optically transparent antennas designed from conductive nanowires.