

Advanced Metasurface for Radio Wave Transmission in Low-Emissivity Glass

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Two decades past, professor Smith and his colleagues showed that the effective refractive index of microwaves with a wavelength of several centimeters is negative. Since then, metamaterials and metasurfaces have been extensively studied. In the field of radio waves, the miniaturization of antennas and the development of abnormal reflectors have been put into practical use by making metastructures resonate. On the other hand, glass with high low emissivity (Low-E) is becoming more popular in order to realize a low-carbon society. Low-E glass is made of a thin film of metal such as Ag, which blocks the transmission of radio waves and inhibits indoor wireless communication (Fig. 1(a)). Therefore, we hypothesized that by creating resonance in the metasurface and strengthening the input side radio waves, it would be possible to pass radio waves through Low-E glass (Fig. 1(b)). In this study, we designed a metasurface that strongly resonates with Low-E glass and reported on improving radio wave transmission.

A metasurface was created by forming a copper pattern on a PET film. The pattern was optimized through electromagnetic field simulation using the commercial software HFSS (ANSYS Inc.). The Floquet port was used as the periodic boundary condition for the simulation. In the simulation, calculations were performed by placing the metasurface on double-layer glass containing Low-E coating and sweeping frequencies from 3.5 to 5 GHz. For optimization, patterns were determined using a genetic algorithm (Fig. 1(c)). Then, the pattern obtained in the simulation was used to create a copper pattern on a PET film using photolithography. The double-glazed glass containing Low-E coating was made by Nippon Sheet Glass. The metasurface was evaluated by attaching it to the Low-E glass inside an anechoic box and using a network analyzer (N9934C, Keysight Technologies).

Through optimization using a genetic algorithm, 1,590 patterns were obtained. We were able to identify 13 types of patterns that increased radio wave transparency by 10 dB or more based on double-layer glass including Low-E coating. When we investigated the electromagnetic field distribution in the obtained patterns, we found that radio wave transparency increases due to the development of a resonance mode between the pattern and the Low-E coating. In addition, when we compared the results obtained with the network analyzer to the simulation results, we found similar outcomes. We also plan to report on the evaluation of the obtained metasurface in a real environment.

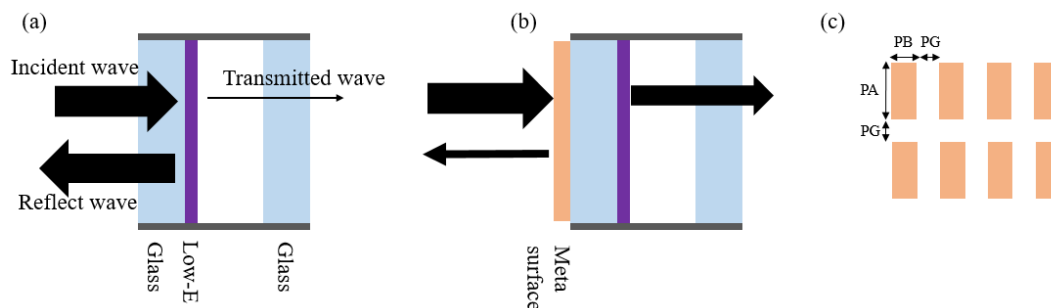


Fig. 1 Radio wave transmission through Low-E glass using a metasurface. (a) is the state of radiowave transmission through low-e glass. (b) is radio wave transmission when a metasurface film is attached to low-e glass. (c) is a metasurface pattern. PA, PB, and PC are parameters used in the simulation.