Design and fabrication of functional cross-shaped metamaterials using electron beam lithography for applications in infrared shielding windows and 6G communications

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Windows with a passive layer of metamaterials (heat shield metamaterials) use less energy to maintain a comfortable indoor temperature. With effective solar energy management, the heat shield metamaterials layer avoids excessive heating inside a building or vehicle by reflecting near-infrared radiation from the sun while maintaining visible light transmission over wide viewing angles. The infrared shielding must be done in order to avoid overheating. Furthermore, infrared radiation must also be reflected rather than absorbed to illuminate the re-emission of the absorbed heat into the room. In this study, the heat shield windows employed an array of aluminum cross-shaped metamaterials (CSMMs) on a quartz substrate, which was fabricated based on MEMS technology with the employment of electron beam lithography. Optical responses were characterized experimentally. The numerical calculation was also performed and the results showed good agreement with the experiment.

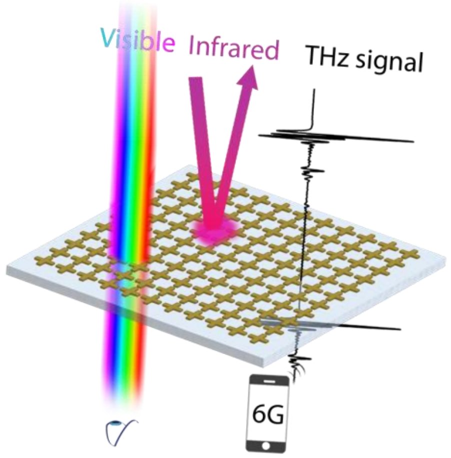

Figure 1. Schematic illustration of the heat shield CSMMs for 6G communications.

FIG.1 describes the schematic illustration of the heat shield CSMMs for 6G communications, which describes the functions of the cross-shaped with high transparency efficiency at visible and terahertz wavelength ranges. FIG.2 shows micro-images of the as-fabricated CSMMs, which show long-range order on the large area. FIG.3 shows the experimental optical characteristics of the CSMMs in the visible, near-infrared, and terahertz wavelength range. High visual transparency (>60%), infrared reflectivity (>80%), and low infrared absorption (<20%) were achieved over a wide range of oblique incident angles (0-60^{o}) for the CSMMs. In addition, high transmittance of terahertz wave (>50%) over a wide range of oblique incident angles (0-60^{o}) in the frequency range of 0.2-1 THz was achieved, which is suitable for applications in communications beyond 6G.

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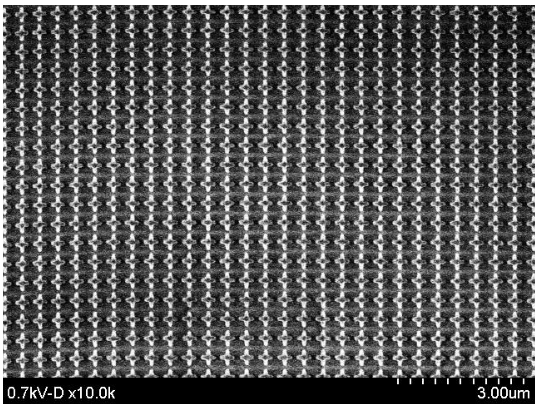

Figure 2. SEM image of fabricated the CSMMs array at a magnification of 10000^{x}.

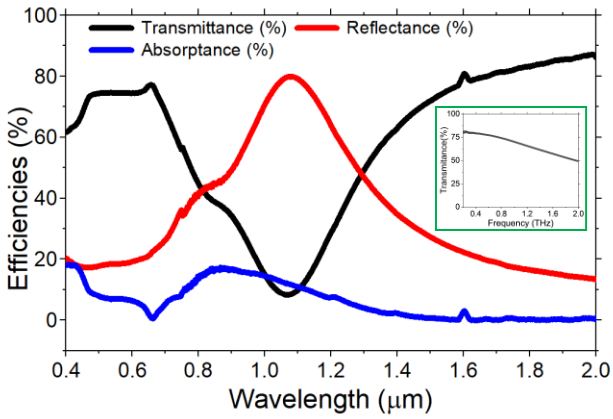

Figure 3. Experimental measurement of optical characteristics of the CSMMs in the visible and near-infrared region. An inset image shows the transmittance spectrum in the terahertz wavelength range.