Pyramidal Corrugations as Wideband, Wide-angle Radomes for Millimeter-wave Automotive Radars

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Automotive radar sensors are experiencing an explosive rate of adoption by the industry and consumers in the past few years. Started from applications for convenience such as lane change warning, blind spot alert and crash alert, parking aid and adaptive cruise control, they are now being used for high-end safety features which will eventually lead to semi- and fully automated, self-driving vehicles. As the complexity of the radar sensing problem grows with consumer demand, higher carrier frequencies for improved angular, radial range and range rate measurement resolutions are needed to ensure the radar signal quality for any dynamic scene. Today, automotive radars mostly use the 76 to 81 GHz band for various radar mode applications (e.g. long, medium, short and ultrashort range mode) in addition to previously used 24 GHz band. The radar transceiver systems are integrated in a chip based on ultrafast electronics and are packaged in a plastic casing and subsequently placed behind front and rear bumpers of the car. As such, the mm-Wave radar signals are prone to the high reflections caused by the radar cover (or radome) and the bumper materials in this frequency band. For accurate operation of the complete radar system to verify full scene coverage, such reflections must be minimized to ensure optimal radar sensor performance.

To address the perennial radome problem for automotive radars, thin matching layers were placed over the radar casing as anti-reflection coatings (F. Fitzek et al. “Comparison of matching layers for automotive radome design.” Adv. Radio Sci., 8, 49-54, 2010). Generally, single anti-reflection layer acts as a quarter-wave transformer and optimizes reflection for one single frequency and direction. For broadband optimization and for a large field of view coverage, multiple layers with varying permittivity are required. However, it is quite difficult and costly to fabricate multiple substrates on top of the rudimentary plastic cover of the automotive radar.

In this work, we present periodic corrugations, fabricated in form of pyramid structures directly on the radar cover to minimize reflections in mm-Wave automotive radar radomes. These structures were inspired from nature to increase transmission by trapping the incident light (AR Parker et al., “Biomimetics of photonic nanostructures.” Nature Nanotechnology, 2, 347-353, 2007). A 2D array of square pyramids placed over the plastic cover was optimized to achieve minimum reflection for wide range of incident angles and across the operating frequency band of 76 to 81 GHz. We also study an alternative structure, namely the inverse pyramid which is much easier to manufacture and achieves similar performance as the pyramid structure. These simple structures are shown to achieve minimal reflections from the radar cover and can be used to realize optimal radomes with insignificant performance impact on the automotive radar sensor.