Anti-Reflective SUEX Coatings of Silicon Optics for mmW and THz Applications

Seckin Sahin*, Niru K. Nahar, and Kubilay Sertel
ElectroScience Laboratory, The Ohio State University
1330 Kinnear Rd, Columbus, OH, USA

Lens-integrated antennas have been instrumental in achieving highly directional radiation patterns from relatively small radiating structures, such as dipoles, patches, and spirals. As such, these antennas are highly desirable for millimeter-wave (mmW) and terahertz (THz) applications. Components made of high-resistivity silicon (HRSi) are mostly preferred for THz optics due to their low-losses and established high precision manufacturing techniques. However, the relatively-high dielectric constant of HRSi (ε_r=11.7) leads to large impedance mismatches at the silicon-air interface, allowing only 46% transmission of the incident power.

To effectively minimize this high reflection loss, anti-reflection (AR) coatings are used. A simple quarter wavelength transformer (QWT) matching layer can significantly improve the impedance mismatch and increase overall antenna gain. Polymers are best suited as AR coating on HRSi optics, thanks to their favorable dielectric properties in mmW and THz bands. Among them, vacuum-deposited Parylene-N has been studied as AR coating on Silicon (A. J. Gatesman, J. Waldman, M. Ji, C. Musante, and S. Yngvesson, IEEE Microwave and Guided Wave Letters pp. 264-266 2000). However, the required AR thickness for mmW and THz bands are well above few 10s of micrometers, and such thicknesses cannot be easily fabricated using the conventional thin film deposition techniques. Nevertheless, several other polymer alternatives are available which can be easily fabricated to desired thicknesses. Among them, SUEX, an epoxy based dry photoresist is a particularly attractive choice thanks to its easy and quick application.

In this work, we developed a straightforward and repeatable fabrication flow for SUEX layer on both flat and curved Silicon surfaces. We first present the measured dielectric properties of SUEX films for mmW and THz bands, and optimized the thickness of SUEX AR coating for 220-320 GHz band. Next, we demonstrate that the transmission through the bare HRSi and SUEX coated HRSi as high as 90% at 270 GHz using a commercial THz time domain spectroscopy system. Additionally, we present a vector network analyzer-based measurement set-up to measure the reflection from HRSi - air interface with and without SUEX AR coating. We show that the air-Silicon interface reflection can be reduced by 10 dB when the hemispherical lens surface is coated with SUEX. Moreover, both transmission and reflection measurements are in a strong agreement with our multi-layer transmission model simulations. Details of lens coating process and measurements will be presented at the conference.