Experimental Demonstration of Effective Medium Approximation Breakdown in Deeply Subwavelength All-Dielectric Multilayers

We report the first experimental demonstration of anomalous breakdown of the effective medium approximation in all-dielectric deeply subwavelength thickness (d∼λ/160-λ/30) multilayers, as recently predicted theoretically [H. H. Sheinfux et al., Phys. Rev. Lett. 113, 243901 (2014)]. Multilayer stacks are composed of alternating alumina and titania layers fabricated using atomic layer deposition. For light incident on such multilayers at angles near the total internal reflection, we observe pronounced differences in the reflectance spectra for structures with 10- vs 20-nm thick layers, as well as for structures with different layers ordering, contrary to the predictions of the effective medium approximation. The reflectance difference can reach values up to 0.5, owing to the chosen geometrical configuration with an additional resonator layer employed for the enhancement of the effect. Our results are important for the development of new high-precision multilayer ellipsometry methods and schemes, as well as in a broad range of sensing applications.