Polymer Based Hybrid Composites for THz Applications

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***Abstract*—In this study, the optical properties of the polymers are enforced by high performance inorganic particles, by utilizing their scattering property and refractive index tunability, a femto-second (fs) laser/THz radiation separating filter and broadband anti-reflective (AR) coating are realized.**

I. INTRODUCTION

Terahertz (THz) radiation is broadly defined from 0.1 to 10 THz, sandwiched between microwave and mid-infrared frequency ranges. The THz radiation has been shown to have considerable potential applications in security inspection, spectroscopic imaging, and future communication systems, etc. Currently, considerable breakthroughs are made; however, the devices for controlling or manipulating THz radiation still remains many hurdles need to be overcome, mainly because of the limited availability of suitable materials. For THz optics, the materials with high functionality, flexibility as well as processibility are highly requested. Organic-inorganic composites are considered to be a new class of advanced materials because of their versatile fabrication approaches and potentiality of novel properties, such as optical, nonlinear optical, electronic, magnetic, photovoltaic, and conductive properties. In THz region, many polymers such as polyethylene (PE), polystyrene (PS), and cyclo-olefin polymer (COP) etc. show relatively low propagation loss, however, their applications are limited by their low refractive indices etc

II. RESULTS

As shown in Fig.1, a two-layer structure was designed for fs-laser/THz radiation separation. The first layer is made of hollow quartz nano-particles which can diffuse the incident fs laser thus decrease the power intensity. The second layer comprises of silicon nano-particles and COP polymer, by which the fs laser light will be greatly scattered and absorbed but THz radiation will propagate insusceptibly (Fig.1 (b)). With this two-layer structure a high efficient fs-laser/THz filter was fabricated successfully (the transmittance in THz region is 90%, and in 800 nm region is lower than 0.0009%).

In Fig.2, TiO_2-COP nano-composites for THz broadband antireflection (AR) applications were prepared; the composites not only exhibit good transparency in the range of 0.2–1.6 THz but also have a very large refractive-index tunability of from 1.5 to 3.1. Then, the TiO_2-COP composite was applied on an silicon substrate for broadband AR structures via a hot-embossing process. By the well refractive index matching, a broadband AR layer was fabricated (0.2–1.6 THz, 7% reflection).

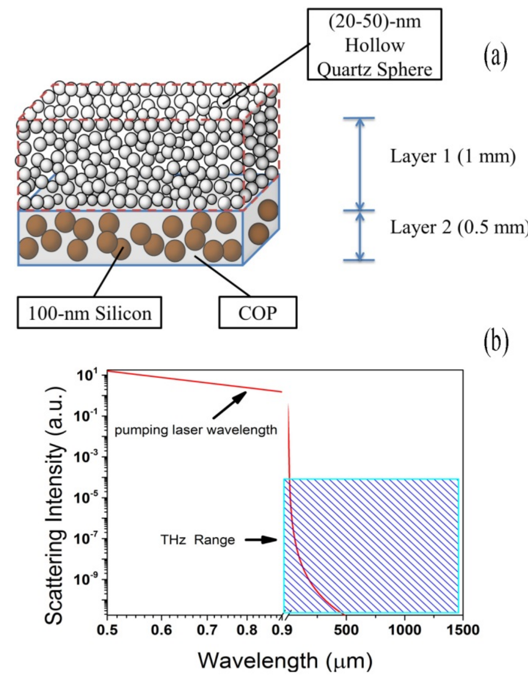

Figure 1 (a) sturcture of fs laser/THz separating filter; (b) Rayleight scattering intensity of fs laser and THz wave.

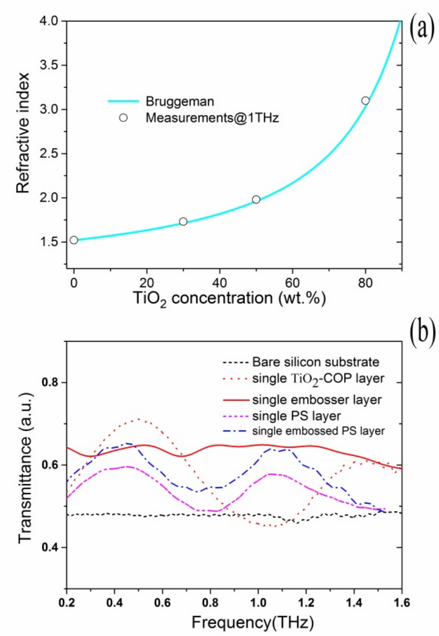

Figure 2 (a) refractive indices of TiO2-COP composites as a function of TiO2 weight ratio; (b) transmittance spectra of high-resistivity-Si coated with different AR layer