Fabrication and Characterization of Hydrophobic SiO_x Nanoparticle Surfaces Using Plasma-Enhanced Chemical Vapor Deposition (PECVD)

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The increasing demand for advanced functional surfaces has accelerated research into the development of durable and controllable hydrophobic coatings. Hydrophobic surfaces, characterized by high water contact angles, have significant potential for applications requiring water repellency, surface protection, self-cleaning properties, and resistance to environmental exposure. Plasma-enhanced chemical vapor deposition (PECVD) offers an advantageous approach for the development of functional surfaces due to its ability to tailor surface properties through the controlled manipulation of plasma chemistry and deposition parhydroph study, the formation of silicon oxide nanoparticles and their effect on the hydrophobicity of coated surfaces were investigated using a capacitively coupled RF-PECVD system. Hexamethyldisiloxane (HMDSO) and oxygen (O_2) were employed as the precursor and reactive gases, respectively. The experiments were conducted at a frequency of 13.56 MHz, a pressure of 180 mTorr, and an RF power of 23 W, while the total gas flow rate was maintained at 50 sccm. The HMDSO/O_2 ratio was systematically varied at 35/15, 25/25, and 15/35 sccm to investigate the effects of gas composition on plasma-phase reactions, nanoparticle formation, surface morphology, and wettability.

The deposition and particle formation processes were analysed using Fourier-transform infrared (FTIR) spectroscopy measurements, while the morphology and surface distribution of the deposited nanoparticles were characterized by scanning electron microscopy (SEM). The wettability of the resulting surfaces was evaluated through water contact angle measurements. The results revealed that nanoparticle formation, surface morphology, and wettability were strongly dependent on the HMDSO/O_2 feed ratio. SEM analyses confirmed the formation of nanoscale particulate structures on the treated surfaces, while spectroscopic and optical measurements revealed the influence of gas composition on particle formation. Notably, a water contact angle exceeding 130° was obtained under the optimized deposition conditions, indicating the formation of a highly hydrophobic surface. These findings demonstrate the significant potential of HMDSO/O_2-based PECVD for controlling nanoparticle formation and developing highly hydrophobic silicon oxide-based functional surfaces through the adjustment of plasma operating conditions.

Keywords: hydrophobic surface; plasma-enhanced chemical vapor deposition; silicon oxide nanoparticles; scanning electron microscope; water contact angle.