Chemical vapor deposition (CVD) may be well suited approach

Traditionally sizing packages are multifunctional and are applied to a fiber surface [1].

An adhesion promoter like organofunctionalized silanes is often a part of these sizing packages, and they can help achieve desirable interphase properties.

Molecular dynamics (MD) simulation studies have shown that these glass-silane-epoxy interphase strength and energy absorption is highly dependent on bond density, interphase-coating thickness, and strain rate (monolayer and fully saturated bond density resulted in highest interphase strength) [2].

Chemical vapor deposition (CVD) may be well suited approach since it can create a uniform silane coating with control of the thickness range as low as a monolayer.

Contacts between the fiber reinforcement and the matrix plays a key role in effectively distributing load within a fiber reinforced polymer composite

Approach

Contact Angle to Understand Change in Surface Chemistry

AFM Images Showing Silane Deposition on Si Substrate for Different Exposure Time

Height Distribution Analyzed through Gwyddion

Contact angle increased 7-10º from 1 min to 10 min as compared to clean substrate.

For deposition time 1 hr to 26 hr the contact angle saturated with an increase of almost 14º.

AFM Images Analyzed through ImageJ

Contact Angle versus Exposure Time

AFM Images Showing Silane Deposition on Si Substrate for Different Exposure Time

Height Distribution Analyzed through Gwyddion

Effective Radius, Counts and Area Covered as a Function of Exposure time

AFM Images Analyzed through ImageJ

AFM Images Showing Silane Deposition on Si Substrate for Different Exposure Time

Height Distribution Analyzed through Gwyddion

XPS

XPS analyzes material between depths of 1 and 10 nm. Since XPS is a surface technique, the orientation of the material affects the spectrum collected.

Coating the silicon substrate with APS decreases the free surface energy thus increasing the CA by 7 to 10º for 1min-10 min and saturates to ~14º at and above 1 hr.

AFM studies confirmed the sporadic distribution at low time intervals and uniform distribution at higher time intervals. The number of nucleation sites increases at low time interval along with effective diameter. While the number of nucleation sites saturate and only growth happens post 1 hr.

XPS studies showed a steady increase in Nitrogen atomic % on silicon substrate with almost 2 fold increase after 1 hr deposition, post which it saturates. C/N ratio was seen to decrease down to ~9 which verifies that most of the signals comes from coating.

More number of island like structure appeared with longer exposure times which seems to saturate post 1 hour.

The increase in effective radius were observed for increase in exposure time indicating growth

Path Forward

- High resolution AFM will be done to understand silane orientations in island like structures
- To calculate the thickness and bond density of the silane deposited as a function of time

References


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