Photocatalytic Surface Initiation for Area-Selective Deposition of Polymer Thin Film and Sustainable Nanomanufacturing

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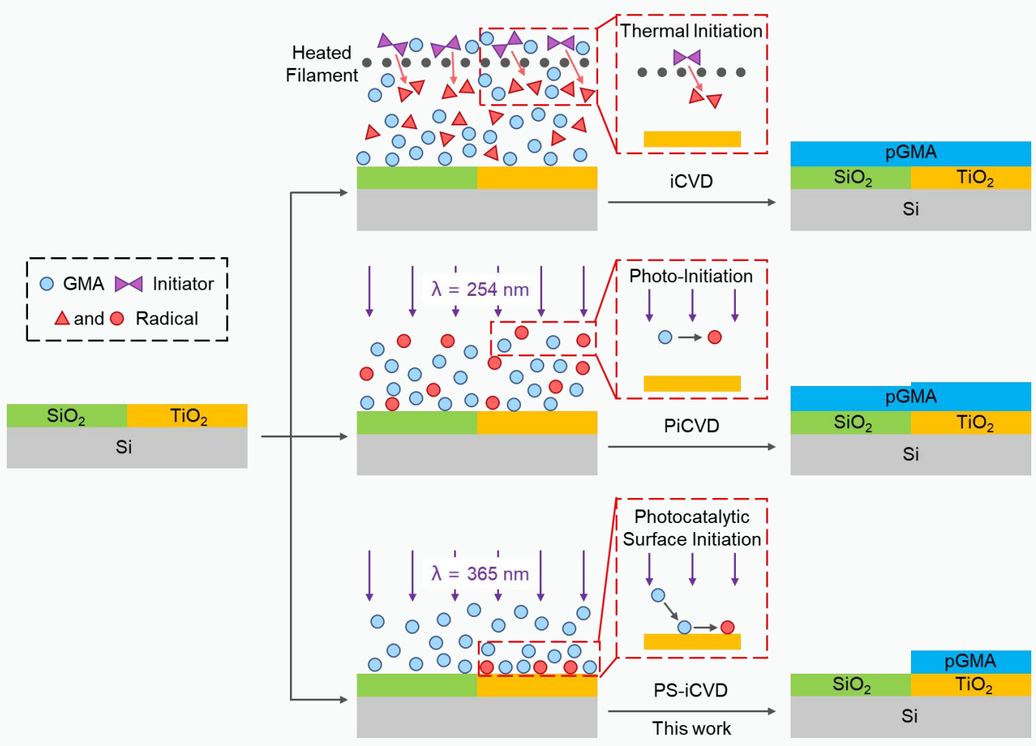
Abstract

Nonlithographic patterning of polymer thin films enables various applications spanning from soft electronics to biomedical engineering. Developing area-selective deposition (ASD) for polymers could achieve self-aligned polymer growth, fostering the generation of complex nanostructures and device configurations with enhanced precision and versatility. However, due to the rapid radical propagation in chain reactions, achieving area-selective radical polymerization in all-dry processes still represents a huge challenge. Here, we report a photocatalytic surface-initiated chemical vapor deposition (PS-iCVD) method. This method can eliminate the need for initiator and localize radical generation on the photoactive surface, which enables ASD of polymer thin films. Moreover, for some visible light active materials, the PS-iCVD strategy can achieve ASD under visible light, which can realize high-purity monomer recycle. Because it is appropriate for various monomers, the PS-iCVD is demonstrated for synthesizing effective anti-corrosion coatings and fabricating self-aligned patterns with high area-selectivity (> 97% at deposition thicknesses more than 40 nm). The PS-iCVD offers placement control over chain-growth polymers, providing insights for guiding the design of eco-friendly deposition methods and bottom-up non-lithographic nanofabrication.

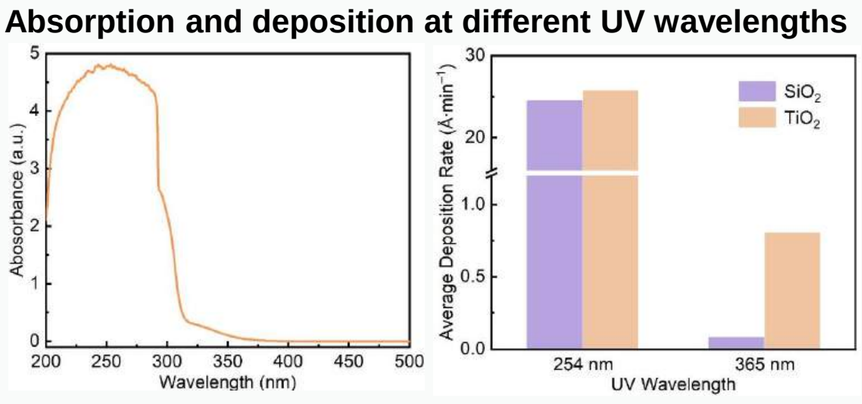
Characteristics of Photocatalytic Surface-Initiated Chemical Vapor Deposition



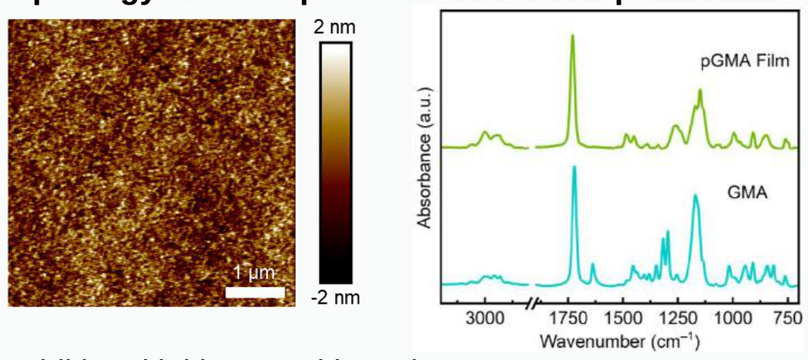
Advantages of PS-iCVD

★ Localized distribution of free radicals ★ Retention of the monomer structure ★ No additional initiator and hot wire

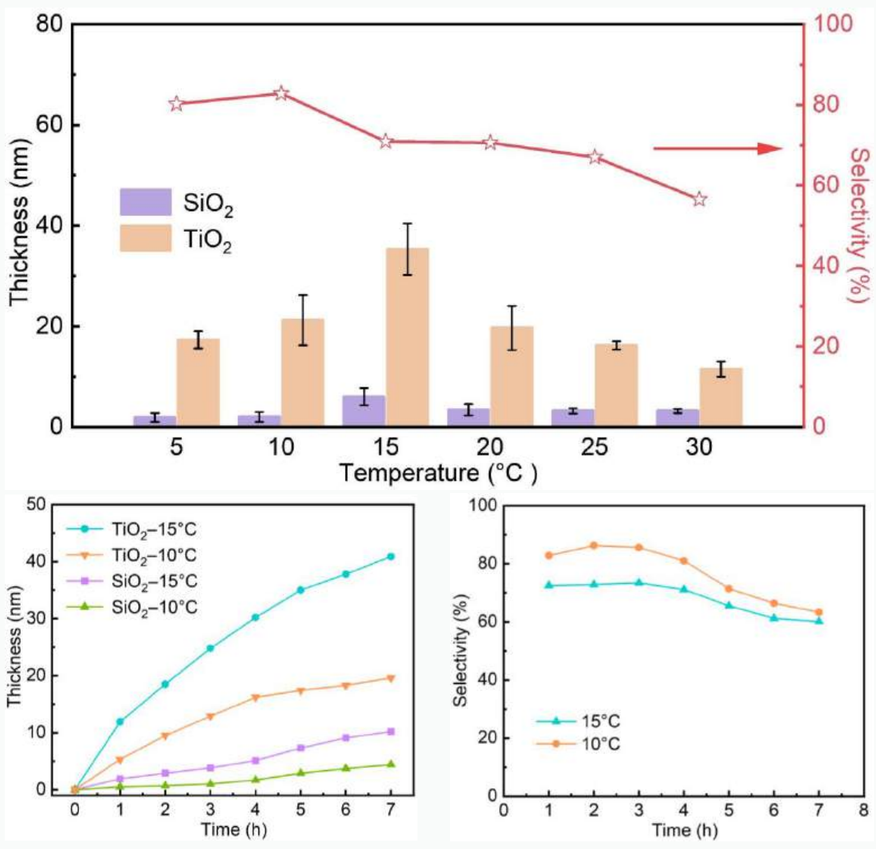
➢ **Absorption and deposition at different UV wavelengths**



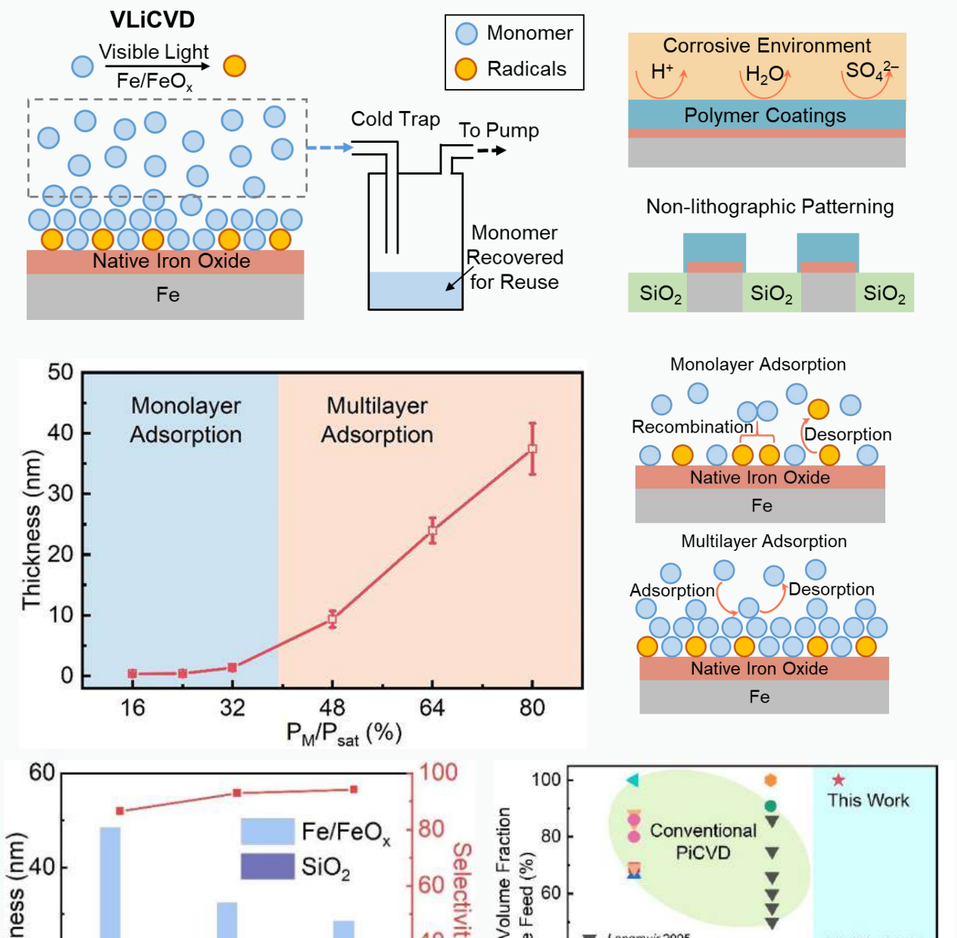
➢ **Morphology and composition of PS-iCVD pGMA film**



Effect of Temperature and Time on PS-iCVD

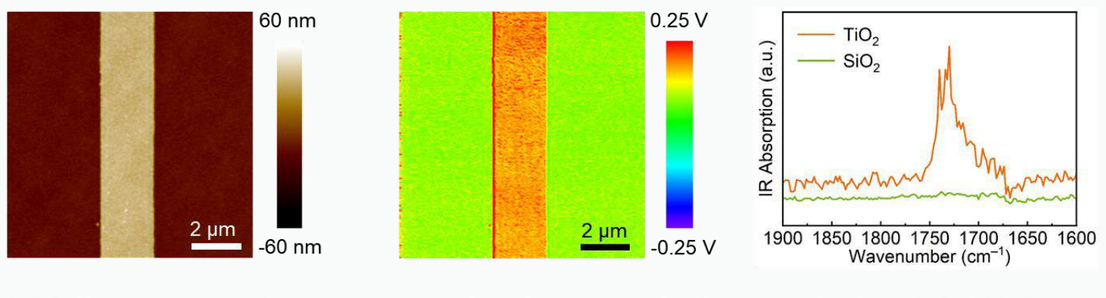


Characteristics of VLiCVD

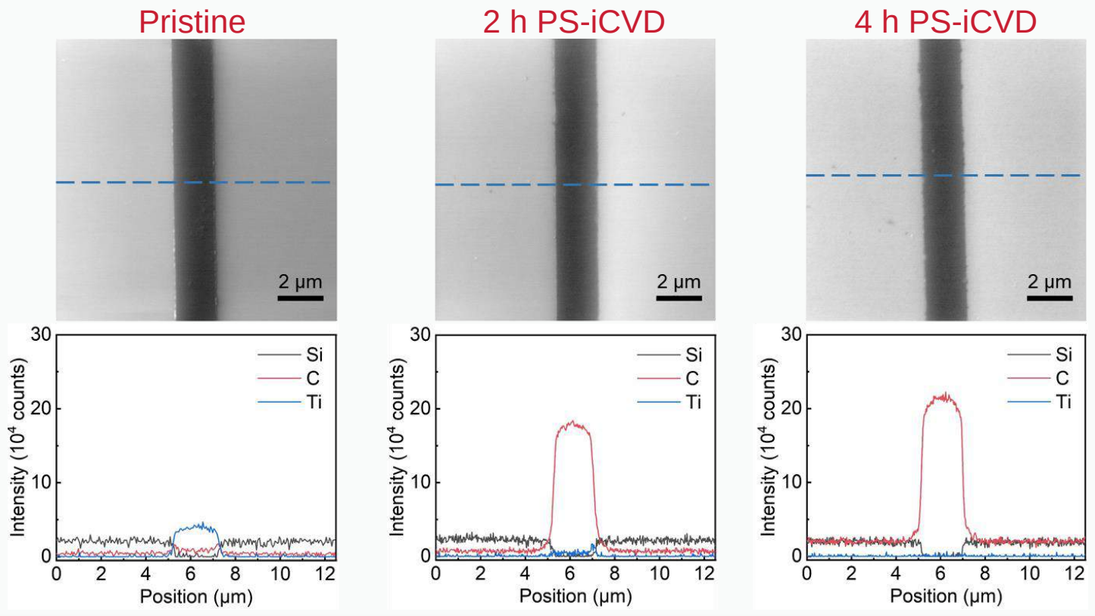


PS-iCVD on Prepatterned TiO_2/SiO_2 Substrates

➢ **Nano-IR mapping and spectra after PS-iCVD**

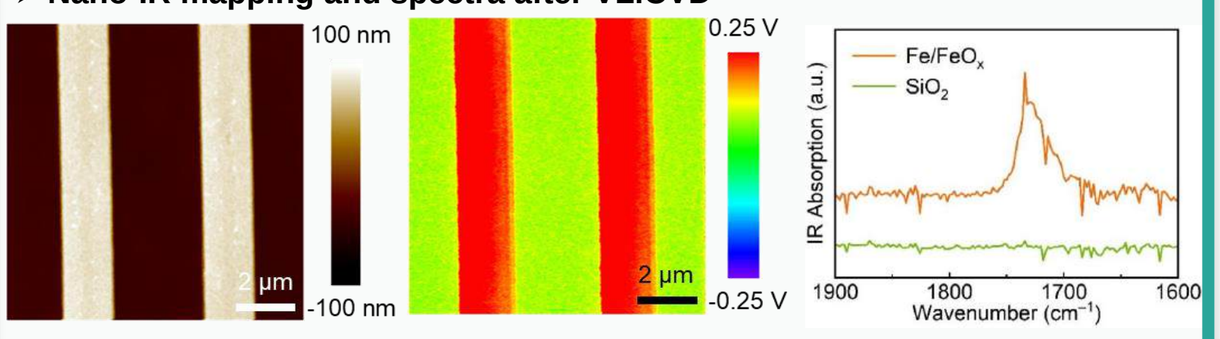


➢ **AES line scans of prepatterned substrates before and after PS-iCVD**

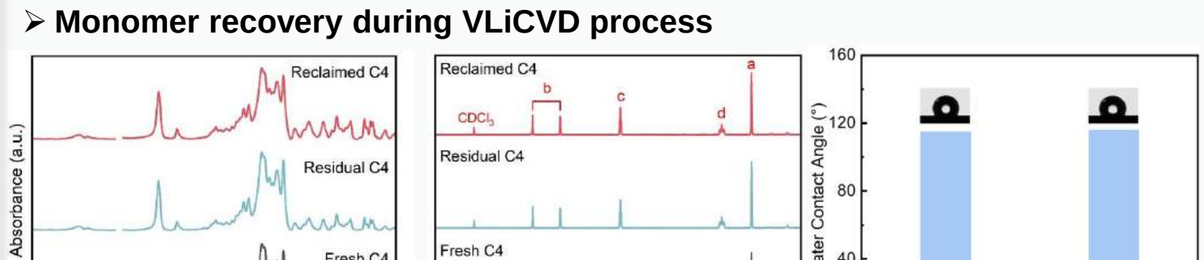


ASD and Monomer Recovery for VLiCVD Process

➢ **Nano-IR mapping and spectra after VLiCVD**



➢ **Monomer recovery during VLiCVD process**



Summary

☑ First report on photocatalytic surface activation for ASD of polymer films

☑ Investigate the effects of substrate temperature, deposition time, and monomer saturation on PS-iCVD process

☑ Providing new opportunities for bottom-up nonlithographic nanofabrication.

Relevant Publication

ACS Materials Lett., 2024, 6, 9, 4058–4065. *Small*, in revision.