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Bond-breaking efficiency of individual MeV-GeV ions in polymer thin films: Combining studies from XPS, FTIR, and AFM-IR

Tuesday, September 23, 2025 9:00 AM (30 minutes)

We report on the evaluation of radiation-induced chemical damage around single ion impacts on thin and ultrathin polymer films using atomic force microscopy–infrared (AFM-IR) spectroscopy and imaging. Radiation effects in polymers are known to involve complex chemical modifications of macromolecular chains, which can be strongly influenced by confinement when the material dimensions are reduced to the nanometer scale. In this work, PMMA films ranging from 2 to 100 nm, deposited on Si, Cr, and Au substrates, were irradiated with swift heavy ions (SHI) and highly charged ions (HCI). IR spectra with characteristic PMMA bands were successfully obtained for films as thin as 10 nm, whereas thinner samples provided insufficient signal for analysis. SHI impacts exhibited pronounced IR contrast, evidencing local chemical damage. However, challenges remain, particularly regarding crosstalk between chemical and topographical features and additional damage induced by the probing IR beam itself. In the case of HCI irradiation, impacts were not resolved in either topography or IR maps, most likely due to the relatively large AFM tip radius (~50 nm). A clear substrate effect was observed: films deposited on Au showed a strong enhancement of IR signal compared to Si. This highlights the critical role of substrate choice in determining signal strength and sensitivity. Overall, these findings demonstrate both the potential and limitations of AFM-IR for probing radiation effects in confined polymer systems and point to future directions for enhancing the technique's accuracy in quantifying nanoscale chemical damage.

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