Electron-Induced Fragmentation of a Tin Oxo-Cluster Model Compound for EUV Lithography

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Extreme ultraviolet lithography (EUVL), operating at a wavelength of 13.5 nm, is now an established technology for high resolution semiconductor manufacturing and is enabling continued scaling of integrated circuits.[1,2] The ionizing nature of EUV radiation produces photoelectrons and cascades of low energy secondary electrons, which can play a central role in the chemical transformations responsible for resist patterning.[3] Consequently, understanding and controlling electron-induced processes is important for the development of next-generation EUV resist materials. Metal-containing resists, and in particular tin-based oxo-clusters, have attracted considerable attention because of the strong EUV absorption of tin and the potential for achieving high resolution and high etch resistance.[4,5] Moreover, the chemical response of these materials can depend strongly on the nature of their organic ligands, making ligand design a possible route for controlling their radiation-induced chemistry.

Here, we extend our previous investigation of dissociative electron attachment (DEA) to neopentyl tris(pivalate)tin(IV), a molecular model compound for tin oxo-cluster resist materials. The compound can be transferred intact into the gas phase and represents a monomeric unit of a typical tin oxo-cluster, providing a suitable system for investigating the intrinsic electron-induced chemistry of these materials. DEA measurements were performed over the 0–12 eV electron-energy range, revealing pronounced and energy-dependent fragmentation. The observed fragment-ion yields are analysed in relation to the underlying temporary anion resonances and the thermochemical thresholds of the corresponding dissociation pathways, calculated at the B3LYP level of theory.

The results are compared with those obtained for butyl tris(tert-butanolate) tin(IV), for which the DEA cross section remains below the experimental detection limit. The contrasting electron-induced behaviour of the two compounds is discussed in terms of their ligand composition and the associated electronic structure and fragmentation pathways. These results provide insight into the molecular factors governing low-energy-electron-induced fragmentation of tin-based oxo-cluster materials and contribute to the development of strategies for controlling and potentially sensitizing their electron-induced chemistry for high-performance EUVL resist applications.

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