Poly(olefin sulfone)s - A Materials Platform for Studying Resist Derived Contamination

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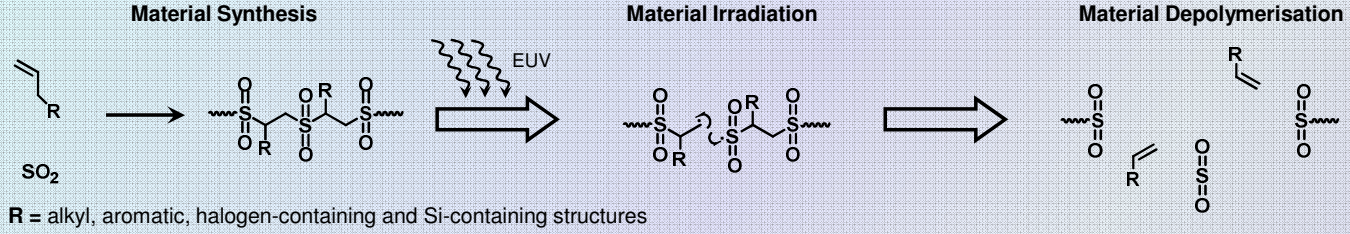
INTRODUCTION

Photoresist derived outgassing species are one of the major concerns for optics contamination in extreme ultraviolet (EUV) lithography exposure tools. However, to date, identifying and quantifying the species, and the levels, which lead to contamination is still a source of debate. The interplay between EUV induced resist material evaporation, interaction of these species with the mirror surface and their degradation at the surface under the influence of EUV light has so far made it difficult to predict mirror contamination based on the chemical structure of the resist. Poly(olefin sulfone)s, formed by the reaction of sulfur dioxide (SO_2) and an olefin, have been identified by us as candidate materials for studying resist-derived contamination.

Poly(olefin sulfone)s
★ EUV irradiation induces **depolymerisation to the parent monomers and SO_2**
★ Provides a **materials platform for studying the contamination** properties of a range of olefin-based structures

AIMS

★ To synthesise and characterise a structurally diverse range of poly(olefin sulfone) materials
★ Evaluate the propensity of the materials to cause contamination of EUV optics mirror surfaces
★ Gain insight into the types of functional groups and molecular structures which lead to mirror contamination



R = alkyl, aromatic, halogen-containing and Si-containing structures

SYNTHETIC METHODOLOGIES AND RESULTS

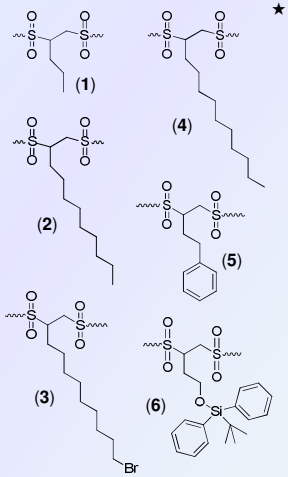
Material Synthesis

★ Materials synthesised via free radical polymerisation using *t*-BuOOH as an initiator

Table 1 – Physical properties of synthesised materials

Material Code	M_n* ^ (Da)	PDI * ^	T_g (°C)
(1)	16 400	1.8	83
(2)	-	-	< 25
(3)	26 900	2.4	< 25
(4)	-	-	< 25
(5)	15 200	2.3	85
(6)	-	-	64

*Obtained using MALS detection on a DMF SEC system.
^Unable to be determined for some materials due to limited solubility in SEC solvents.



Outgassing Degradation Products

★ All materials found to degrade to SO_2 and the corresponding olefin
★ All materials show significant outgassing

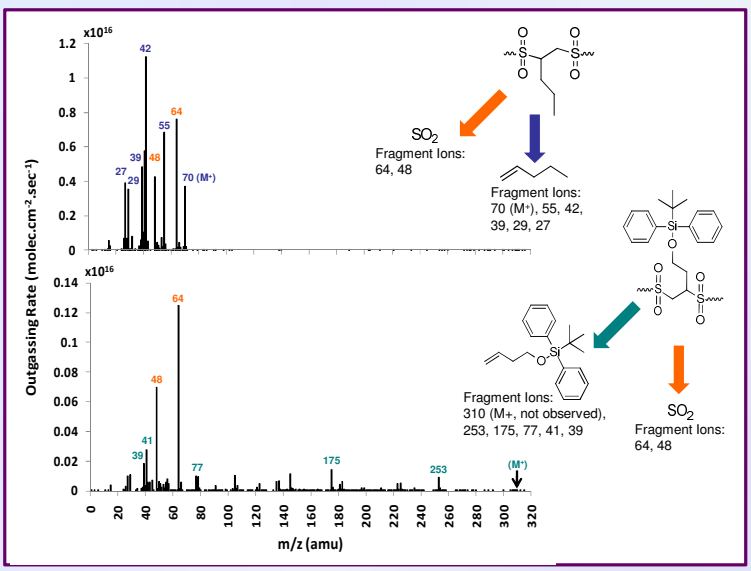


Figure 1 - Outgassing species from materials (1) and (6)

Witness Plate Contamination Studies

★ Increasing monomer molecular weight leads to an increase in contamination
★ Relationship between outgassing rate and contamination (carbonization rate) depends on olefin molecular weight and functional groups present

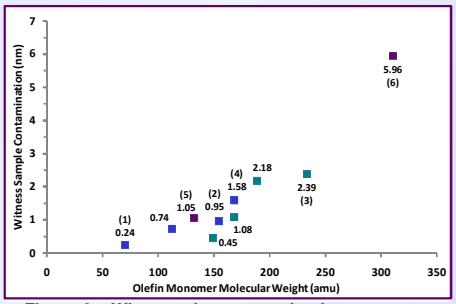


Figure 2 – Witness plate contamination verses olefin monomer molecular weight

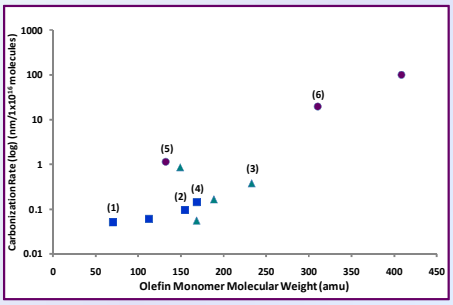


Figure 3 – Carbonization rate verses olefin monomer molecular weight

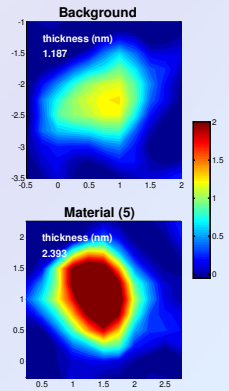


Figure 4 - Example of thickness measurement by ellipsometry over background (top) and material (5) (bottom) contaminated areas of the witness plate.

CONCLUSIONS & FUTURE WORK

★ Synthesis of a **structurally diverse range of poly(olefin sulfone)s** achieved
★ Materials found to **outgas significantly** and **degrade to SO_2 and the corresponding olefin**
★ Witness sample contamination found to **increase with increasing olefin molecular weight**
★ Carbonization rate depends on **olefin molecular weight and functional groups**
★ Poly(olefin sulfone)s provide a **materials platform** which allows investigation of the mirror contamination properties of a **wide range of chemical structures**
★ **XPS measurements** will be used to determine the **nature of the deposited species**

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