Evaluating Ozone vs. Open-Air Plasma Comparisons for Underfill Effectiveness

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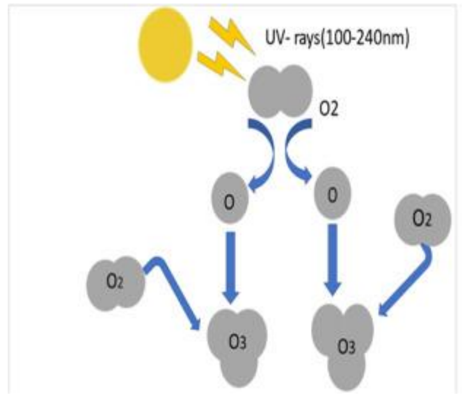
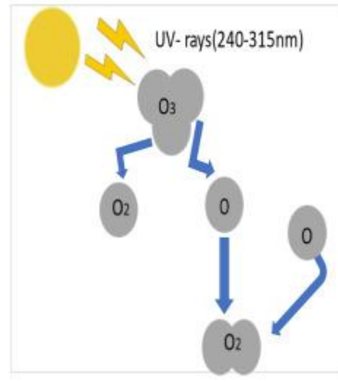
Introduction

Surface preparation plays a critical role in semiconductor manufacturing , where cleanliness and surface energy directly affect film adhesion, coating uniformity, and device reliability. Contaminants such as carbon can reduce oxide quality and hinder the wetting behavior essential for processes like deposition and bonding. This study compares UVO (UV Ozone) and open-air plasma surface treatments to evaluate their effect on carbon removal, oxygen activation, and surface cleanliness. The results help clarify how these treatments influence wettability and surface behavior relevant to semiconductor processing.

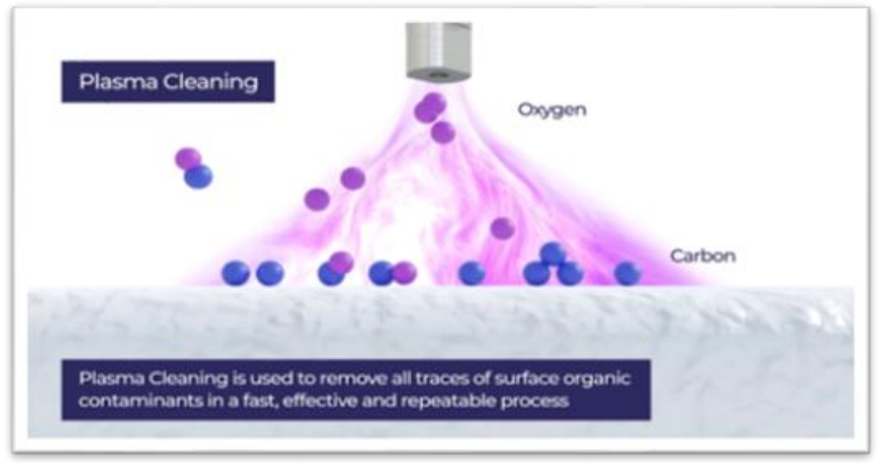
Analysis

Analysis of the stainless-steel and SnO_2-coated samples showed differences in how open-air plasma affected surface composition. Comparing SS1 (untreated) and SS3 (plasma-treated) showed higher surface carbon and slight changes in nickel, likely from redeposition during plasma exposure. In SnO_2-coated samples (SS4 vs SS6), the oxide remained stable, but carbon increased and oxygen decreased after plasma treatment. Overall, plasma altered surface chemistry without damaging the SnO_2 layer.



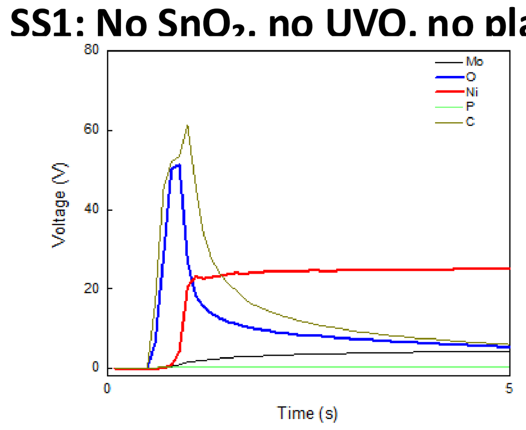


UV ozone (UVO) treatment



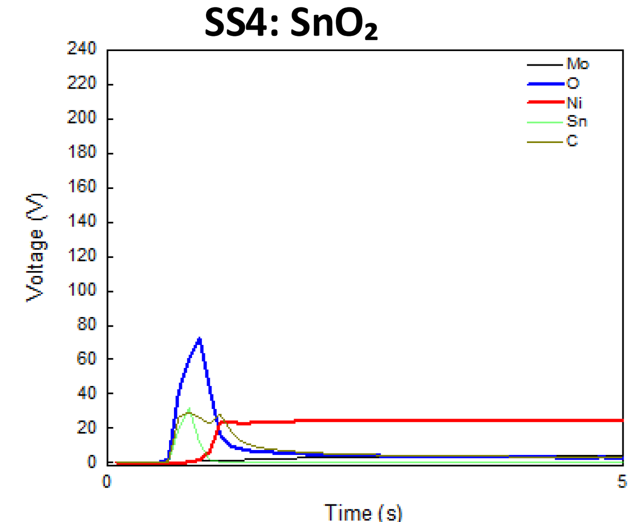
Open-air plasma treatment

SS1: No SnO_2, no UVO, no plasma



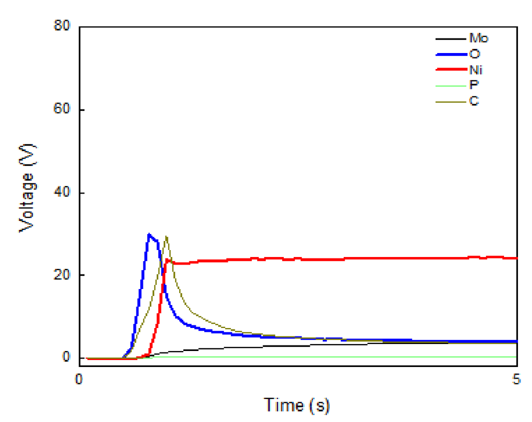
SS1: High carbon presence with strong oxygen presence. Mo and Ni levels are similar, though Mo is much lower; phosphorus remains consistent and low.

SS4: SnO_2



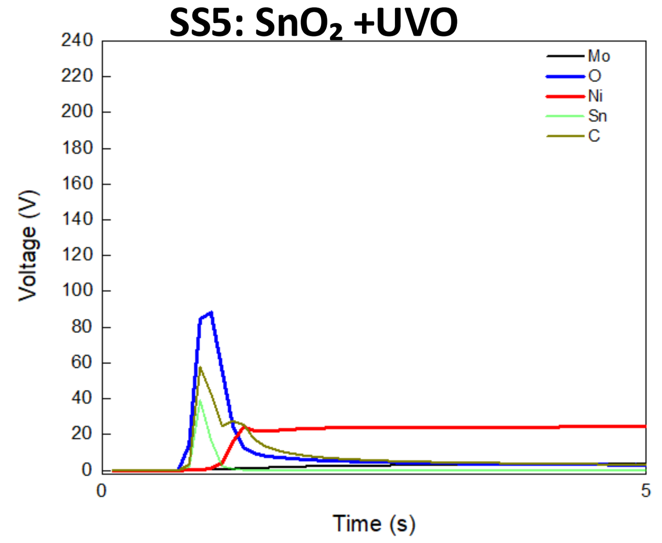
SS4: Tin layer becomes visible above Ni. Oxygen increases, nickel stabilizes, and carbon decreases, showing tin oxide forming.

SS2: No SnO_2, UVO only



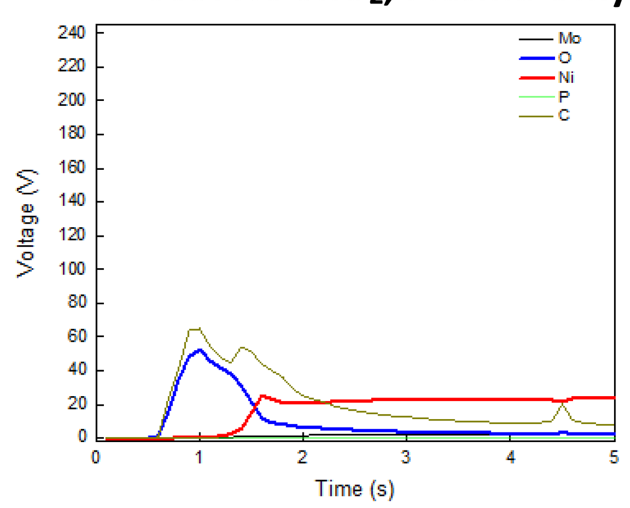
SS2: UV exposure reduces surface carbon and slightly improves oxygen quality and reliability. Phosphorus remains consistent.

SS5: SnO_2 +UVO



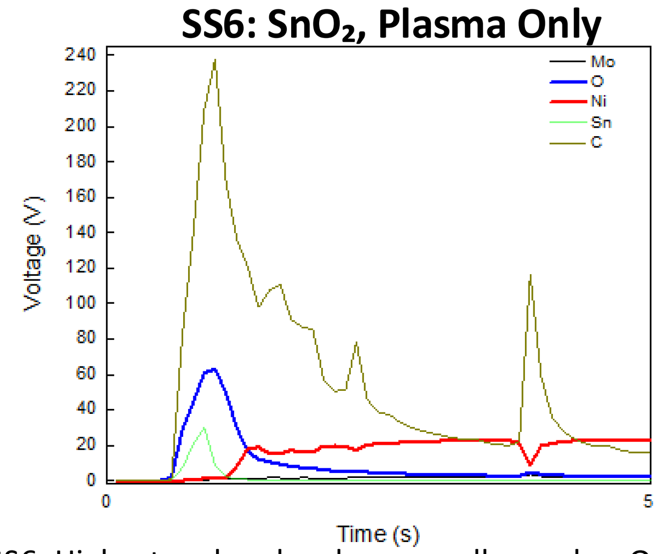
SS5: Carbon is reduced, and oxygen is highest compared to all other measurements which shows enhanced oxide formation from UV treatment. Tin levels match SS6.

SS3: No SnO_2, Plasma Only



SS3: Carbon increases compared to SS1, while phosphorus stays low and consistent. Nickel levels are similar to SS1 and SS2.

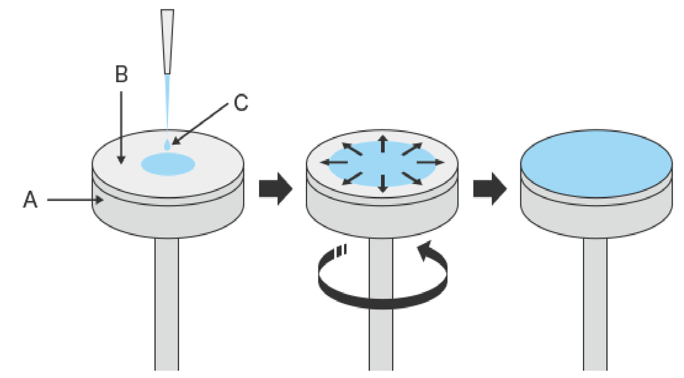
SS6: SnO_2, Plasma Only



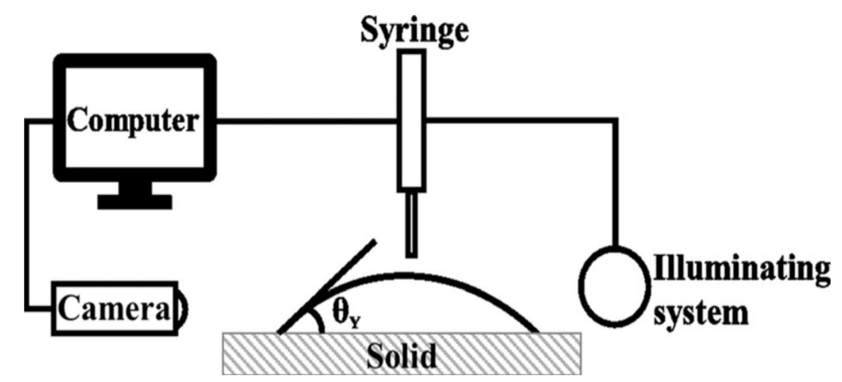
SS6: Highest carbon level among all samples. Oxygen decreases slightly compared to SS4, while Ni remain stable. Plasma likely adds or redistributes surface carbon.

Materials & Methods

Six stainless steel samples (SS1–SS6) were prepared under different surface treatment conditions to evaluate the effects of SnO_2 coating, UVO exposure, and open-air plasma. SS1 served as the untreated control. SS2 was exposed to UVO only, while SS3 received plasma treatment without UV or SnO_2. SS4 included a SnO_2 coating, SS5 had SnO_2 with both initial and secondary UV exposures. Finally, SS6 was coated with SnO_2, exposed to initial UV, and treated with open-air plasma.



Spin coating process



Contact Angle Measuring System

Conclusion & Next Steps

Open-air plasma mainly affected surface carbon levels, while oxygen intensity and the SnO_2 layer remained stable across treatments. The two cleaning methods showed different effects, suggesting that plasma parameters may need adjustment to improve carbon removal. Upcoming work will include silicon substrates with SnO_2 coatings, analyzed using contact angle goniometry, profilometry, and adhesion testing to connect surface chemistry with wettability, surface energy, and interfacial strength.

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Fig 1

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