Reducing Oxygen Absorption in Si-Doped GDP Capsules by Improving Storage Conditions

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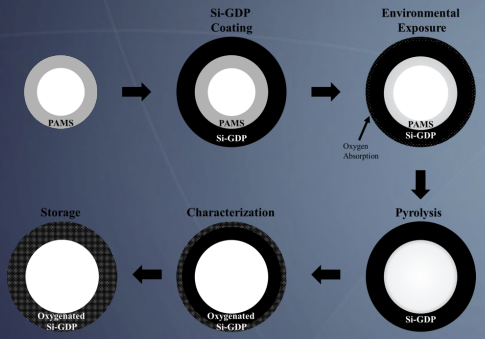
Motivation

Oxygen absorption by thin-film glow discharge polymer (GDP) targets has been shown to be a primary cause for hydrodynamic irregularities during the implosion process. Therefore, minimizing oxygen pick-up during the fabrication, characterization and storage is a high priority.

Previous studies have been conducted to understand oxygen absorption in undoped GDP films, but not much work has been done to understand the oxygen absorption in silicon doped GDP.

As demand for Si-doped GDP capsules continues to increase, the need to understand oxygen absorption by Si-doped GDP will grow.



Experimental Details*

Oxygen absorption over time was studied in ~6% Si-doped GDP under the various storage conditions described below. Undoped GDP films were also measured for reference. Shells approximately 1570 μm in outer diameter (OD) and wall thickness of 27 μm were fabricated using glow discharge polymerization. These capsules were used to measure mass and dimensional changes over time. NaCl substrates were also coated with ~10 μm of Si-doped GDP and undoped GDP, to determine the chemical bonding characteristics using Fourier Transform Infrared Spectroscopy (FTIR).

Material	State	Illumination	Atmosphere
Si-GDP	Pre-Pyrolysis	Light/Dark	Air/N_2/Vacuum
Si-GDP	Post-Pyrolysis	Light/Dark	Air/N_2/Vacuum
GDP	Pre-Pyrolysis	Light/Dark	Air/N_2/Vacuum
GDP	Post-Pyrolysis	Light/Dark	Air/N_2/Vacuum

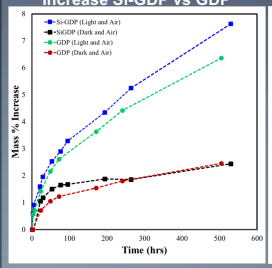
Storage Conditions

Capsules were placed inside alumina crucibles and stored inside plastic petri dishes.

Light: Room Lights
Dark: Petri dishes covered in Al foil
Air: Exposed to lab atmosphere
N_2: Stored in N_2 purge box
Vacuum: Vacuum box (~3 torr)

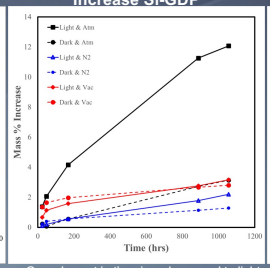
Oxygen Absorption Measured by Mass Change

Pre-Pyrolysis Mass% Increase Si-GDP vs GDP



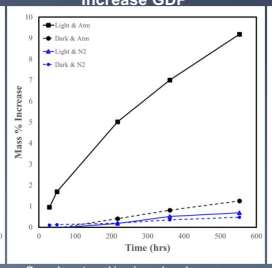
- Obvious grouping between illuminated samples vs. dark samples.
- Dark samples show significantly less mass gain (~3X less) than illuminated samples over the course of 3 weeks.
- Both Si-GDP and GDP show similar trend.

Post-Pyrolysis Mass% Increase Si-GDP



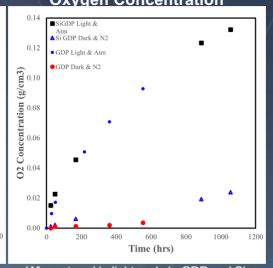
- Capsules out in the air and exposed to light resulted in drastic change in mass resulting in 12% increase over the course of 1056 hours.
- All the other storage conditions appeared to reduce the oxygen pick up drastically, only increasing the mass from between 1.2–3.1% over the course of the 1056 hours.

Post-Pyrolysis Mass% Increase GDP



- Samples stored in air and under illumination gained over 9% mass in 553 hrs.
- The samples not stored under illumination exposed to air demonstrated a less than 1% mass increase over the 553 hours.

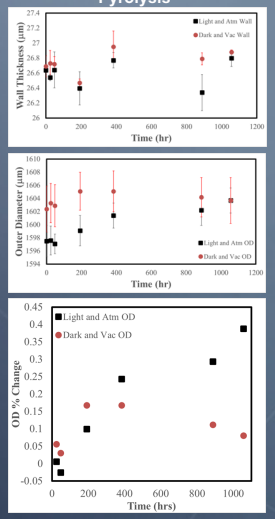
Si-GDP vs GDP Calculated Oxygen Concentration



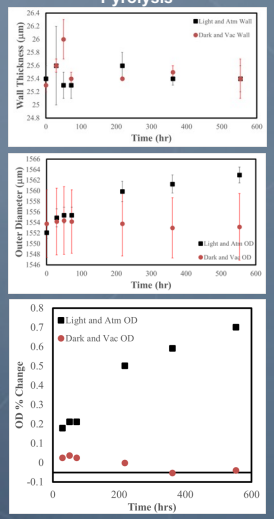
- When stored in light and air, GDP and Si-GDP appear to pick up oxygen at a very similar rate.
- When stored in dark and under a nitrogen purge box, it looks like the Si-doped GDP is absorbing more oxygen

Capsule Dimensional Change through Oxygen Absorption

Si-GDP Post Pyrolysis

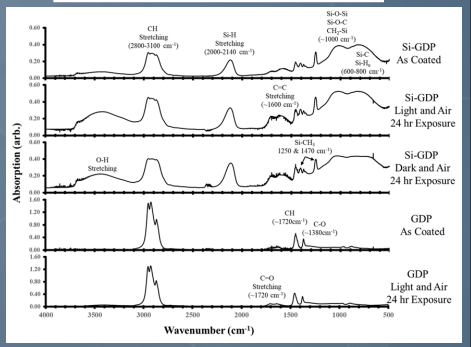


GDP Post Pyrolysis

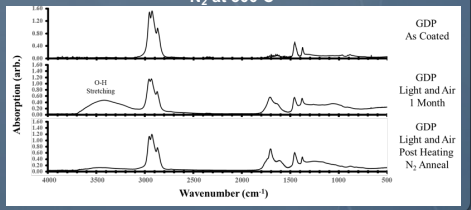


- Si-GDP and GDP outer diameters (OD's) appear to be increasing over time.
- Wall thickness may also be increasing but cannot currently be measured since expected wall growth is within the measurement error.

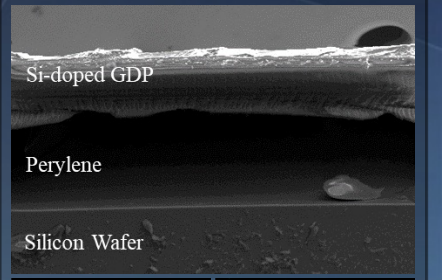
FTIR Results- Chemical Structure

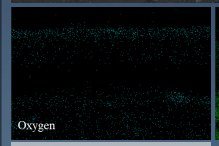


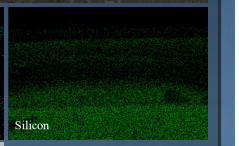
Reversing Oxygen Absorption in GDP by Annealing in N_2 at 300 C

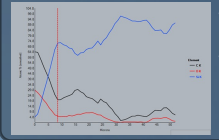


Oxygen Mapping using Energy Dispersive Spectroscopy









- A higher concentration of oxygen can be seen near the surface of the Si-doped GDP film.
- A linear scan reveals the oxygen concentration dropping linearly until approximately 7 μm in depth (approximate thickness of the Si-GDP).

Summary

- Exposure to illumination appears to be the key contributing factor in mass % increase in Si-GDP and GDP films which is consistent with previous results
- Thus far, results demonstrate that there is an increase is oxygen absorption in Si-GDP versus undoped GDP.
- The Si-GDP and GDP thin film shell layers appear to grow over time as well as the capsules outer diameter.
- Si-GDP films show distinct Si-O-Si & Si-O-C absorption peaks in their FTIR absorption spectrums, which may account for the increased mass % increase compared to undoped GDP films.
- It was shown that the oxygen content can be reduced after long term air exposure by annealing the thin film in nitrogen gas.

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