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Performance and Reliability of Silicone Polymers in 1000X Concentration CPV Applications

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Silicone serves multiple functions in the Emcore CPV module

adhesive

moisture barrier

optical coupling adhesive

Fresnel lens

electrical encapsulant

Emcore CPV system analysis targets specific materials/interfaces for further interrogation

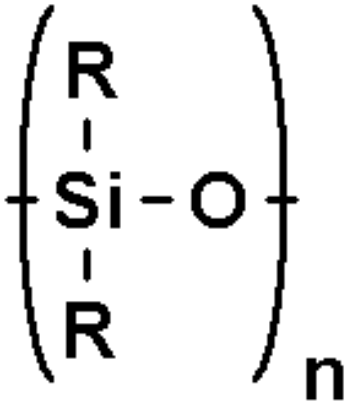
Analysis of the potential weak links in the CPV product have identified silicone needing further reliability testing

As a III-V cell manufacturer, Emcore has a deep knowledge base to draw from during reliability assessments

Due to the nature of CPV, traditional stress acceleration to failure isn't always an option – health monitoring is needed

Targeted testing of other potential concerns is underway using appropriate stress tests

Silicone is a robust material, but is highly stressed in the 1000X light path



Properties:

use temperature < 200ºC

thermal conductivity = 0.16 W/m·K

Operating Conditions:

1000X concentration

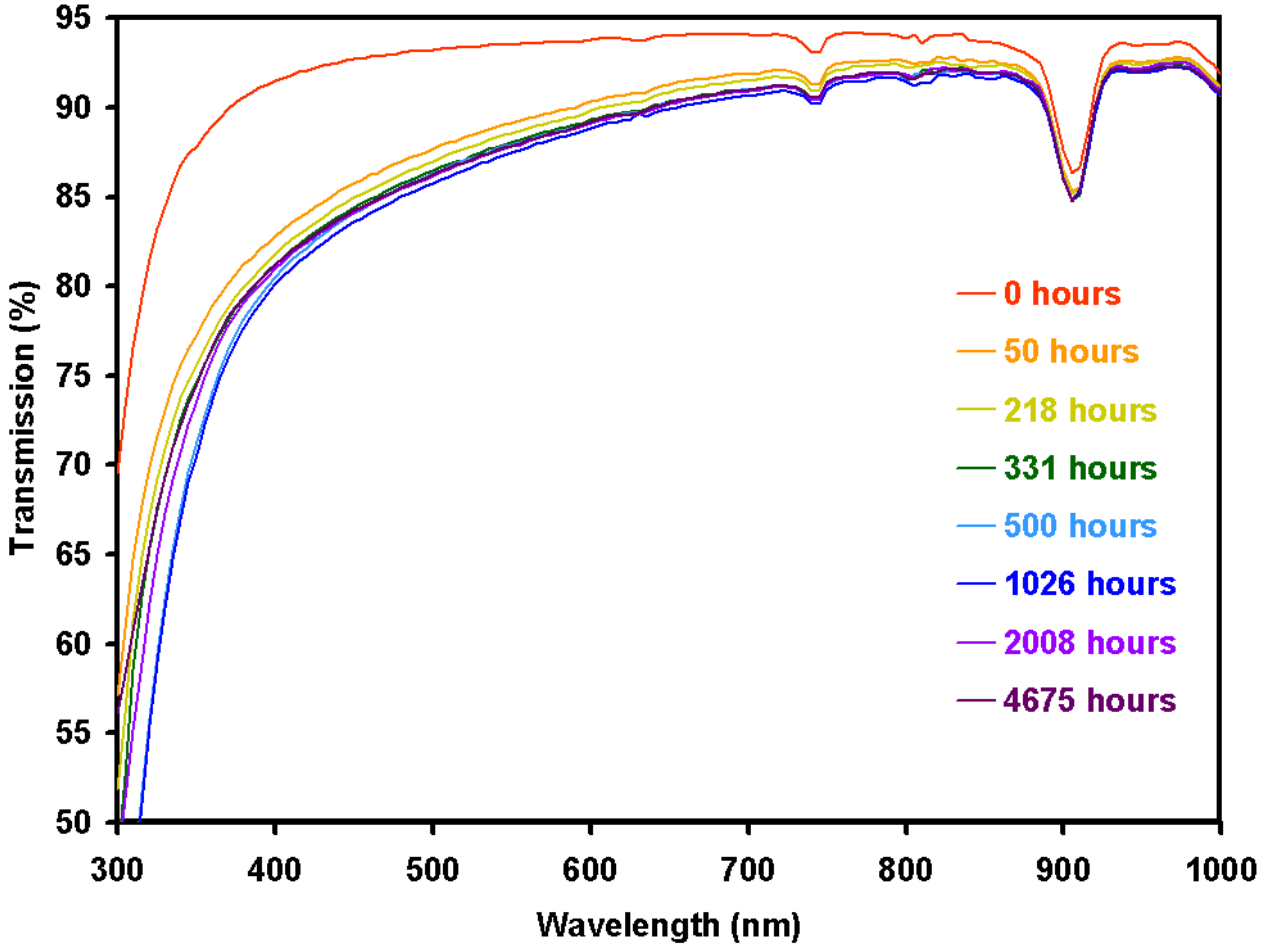
occasional high temperature

contact with other materials

Do these properties apply at 1000 suns at 80+ºC for 25 years with thermal cycling and humidity?

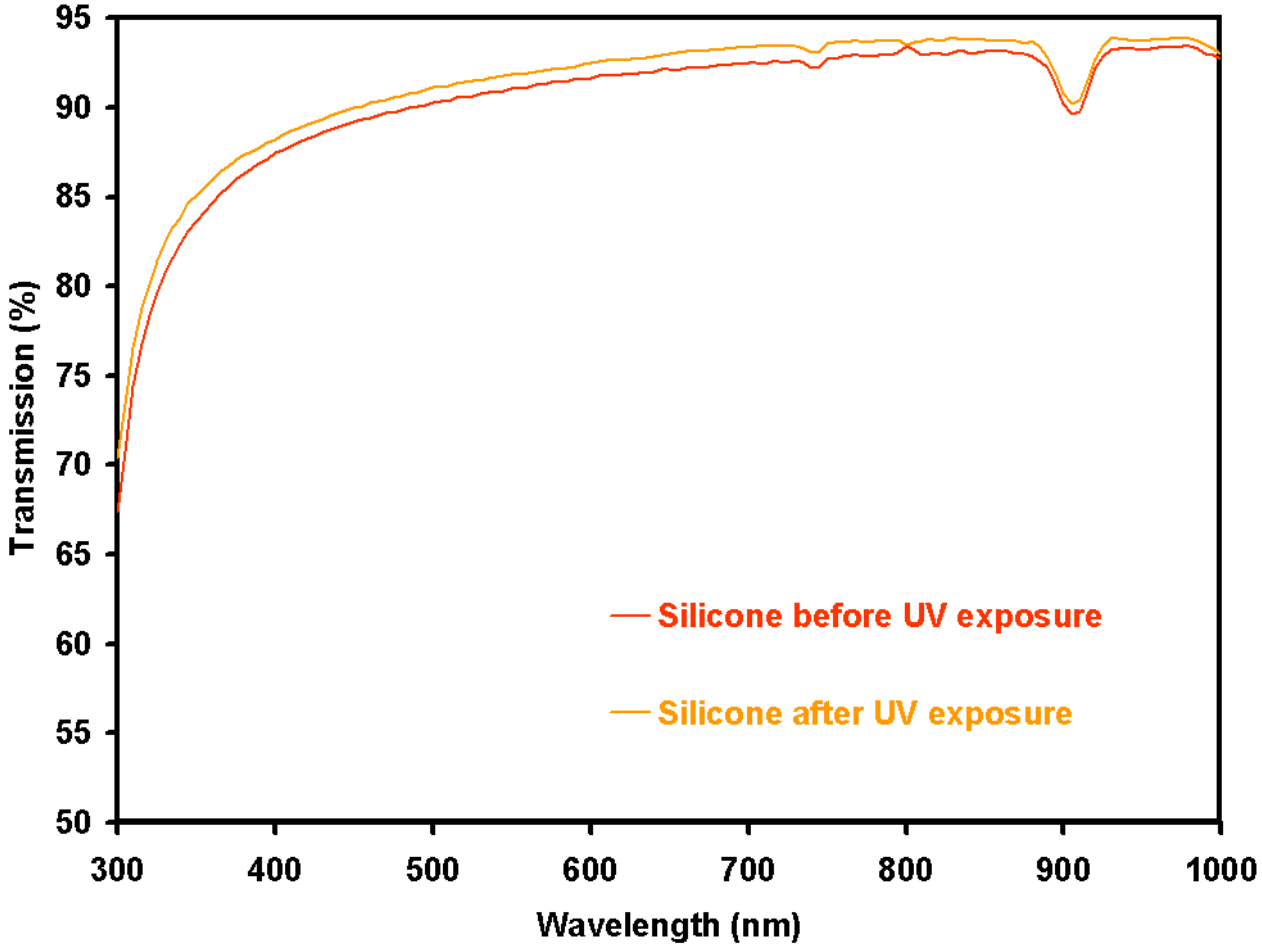
The transmission of silicone decreases shortly after exposure to high temperature

silicone aged at 175ºC in air – 10mm thick



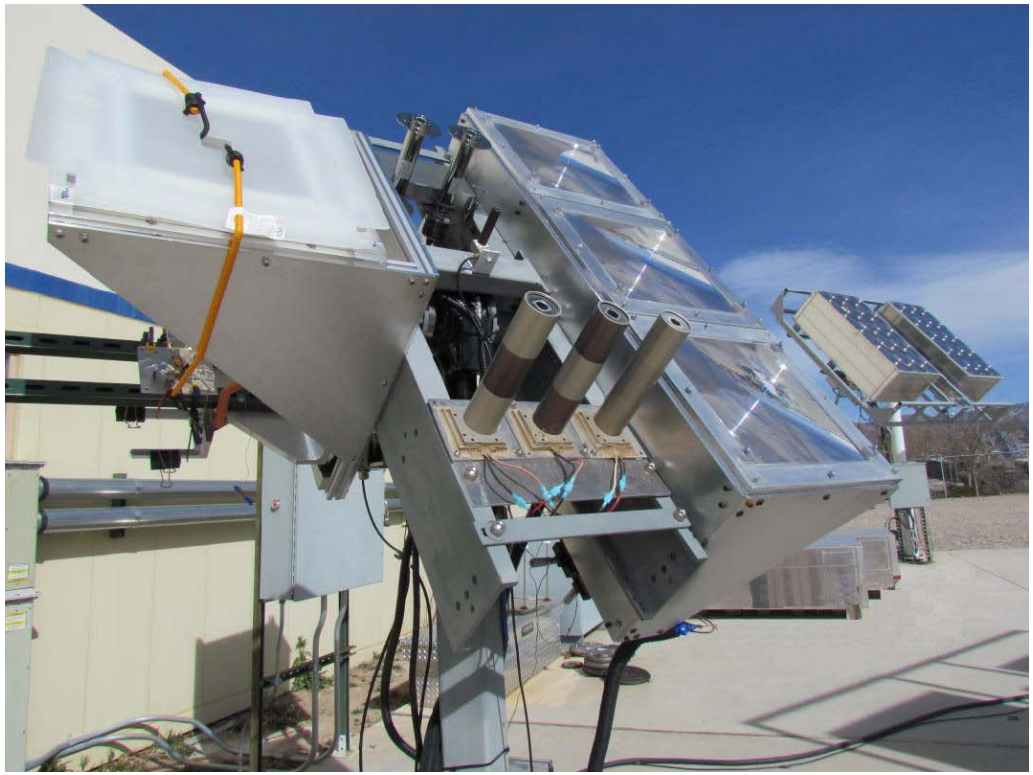
Exposure to UV at ambient temperature has not caused silicone transmission to degrade

sample aged at 175ºC prior to UV exposure at 25ºC, 5 mm thick



Combined effects testing is a more realistic technique to establishing silicone reliability

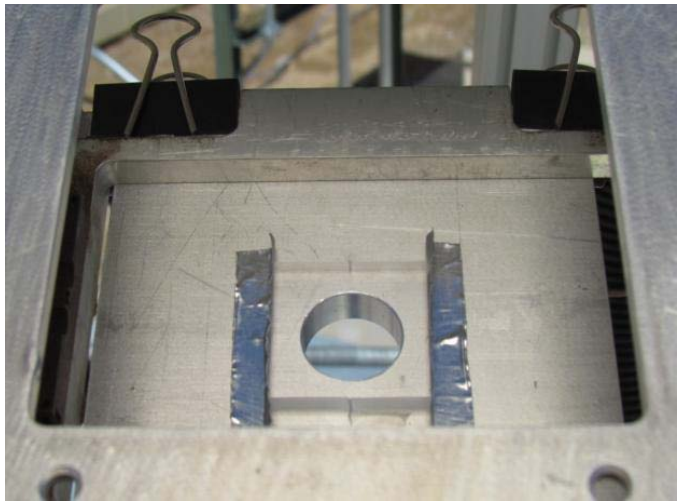
on sun comparison to narrow the field of viable solutions

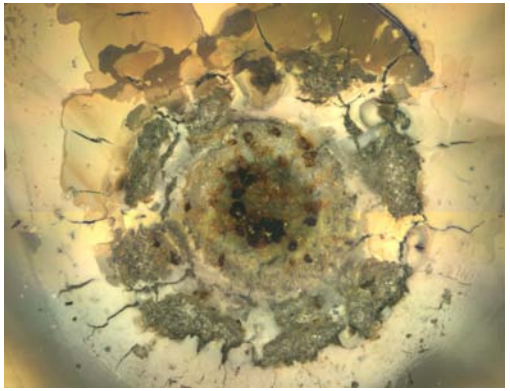


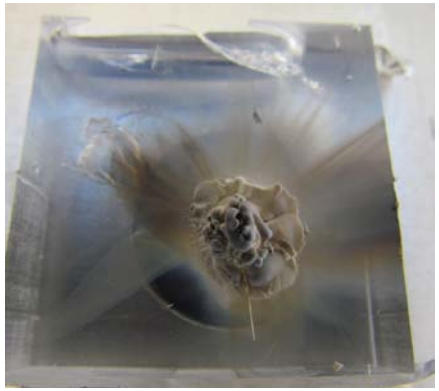
indoor testing for acceleration factors

Bulk silicone testing on-sun yields useful information about silicone degradation

5 mm thick samples tested on-sun in a variety of UV and ambient temperature conditions

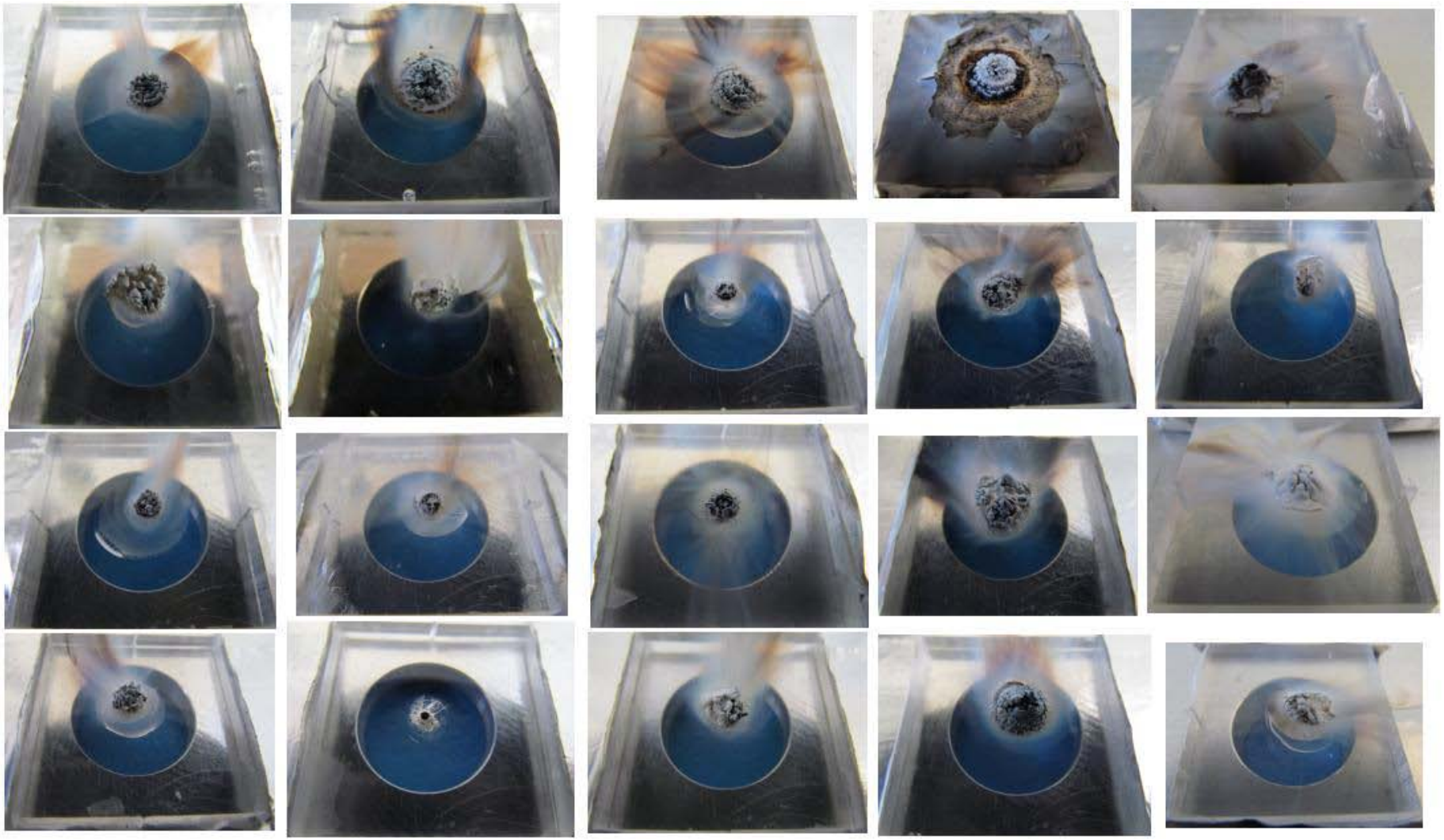




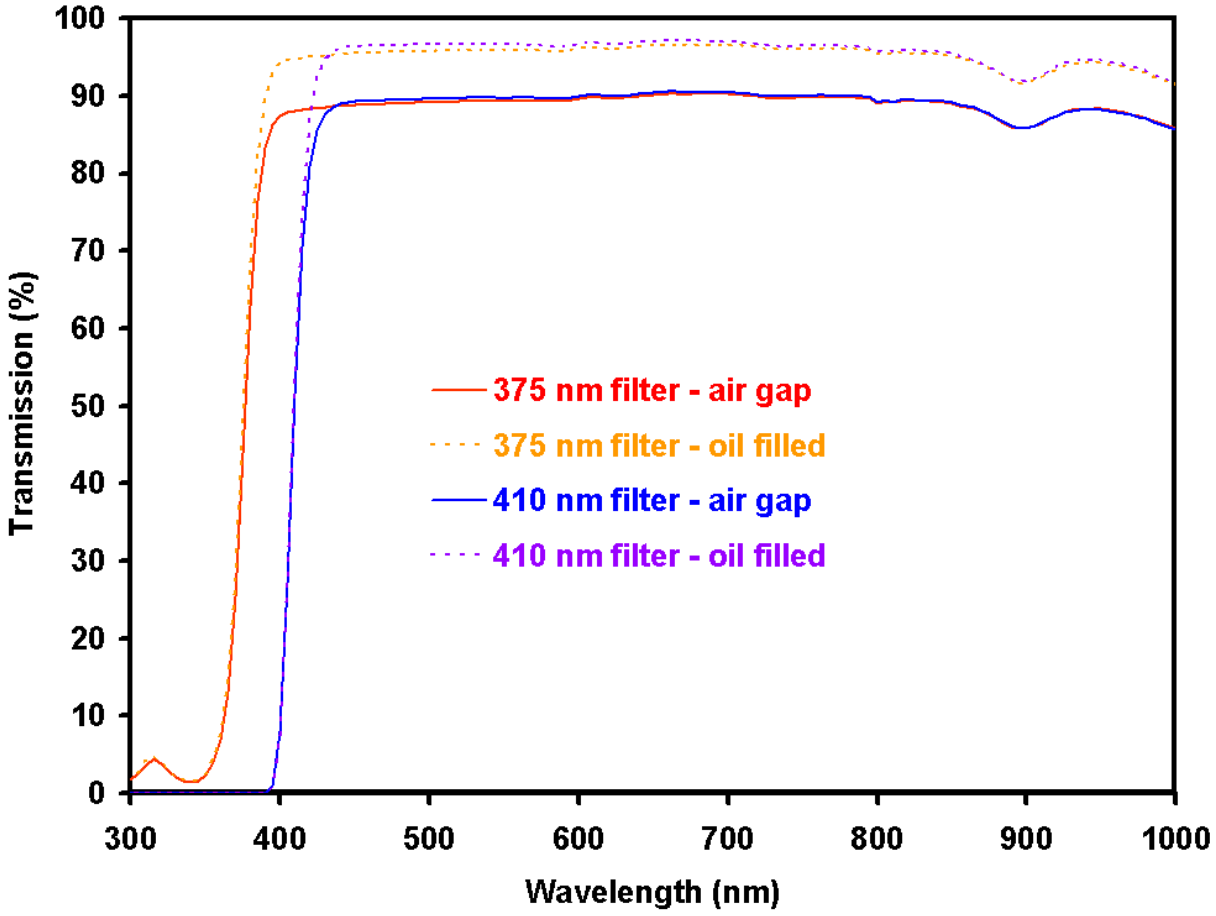
Silicone temperature is not an easy variable to control during on-sun testing

time to decomposition depends on manufacturer and thermal history



UV exposure is controlled through the use of filters during on-sun testing

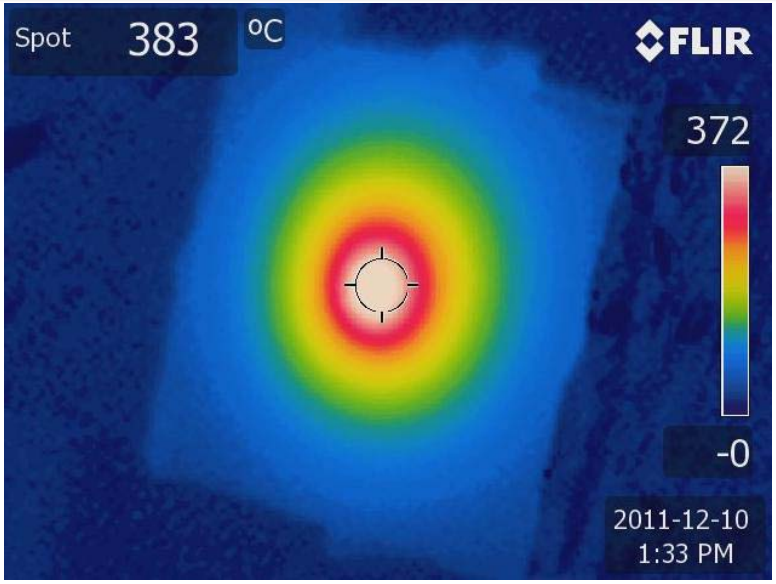
two filters: 50% transmission at 375nm and 410 nm
(30 nm bandwidth between 10% and 90% transmission)

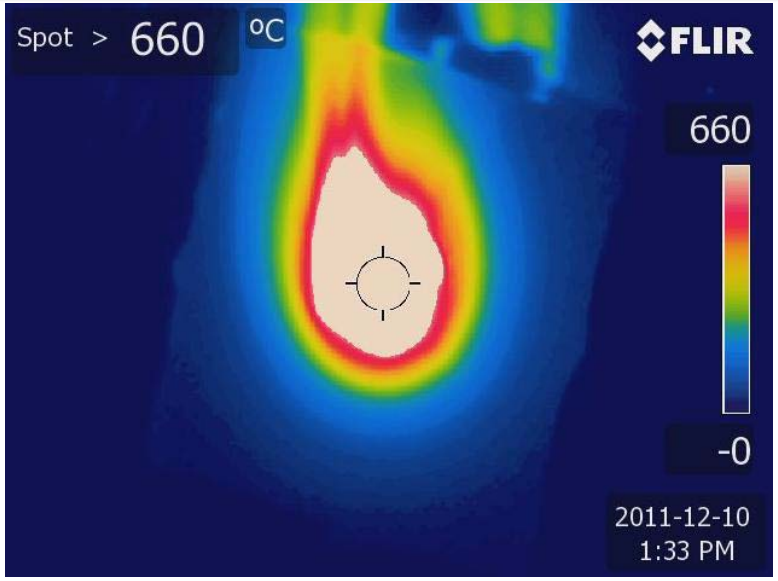


Infrared imaging shows the effect of the UV filter during on-sun testing

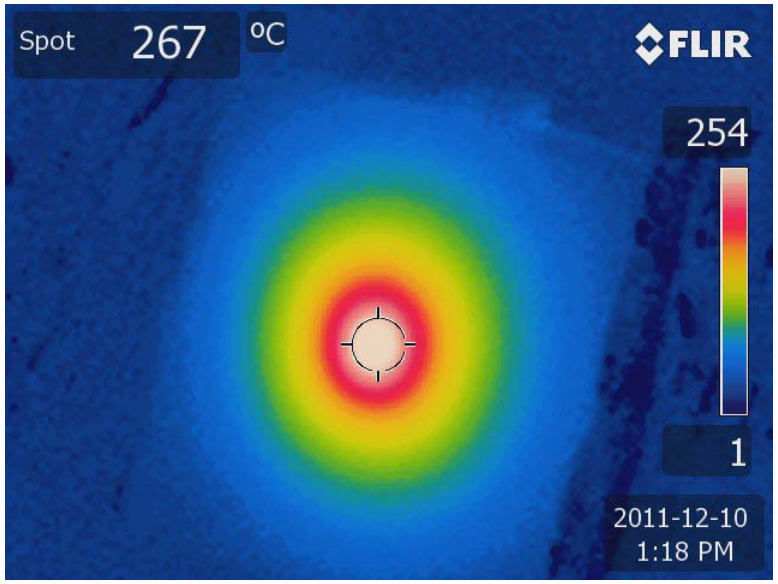
unfiltered

10m on-sun



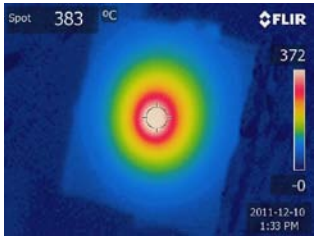


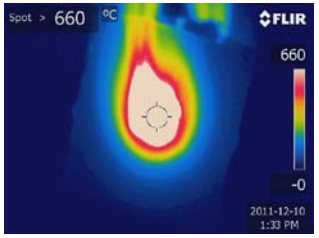
IR imaging of bulk silicone samples shows that inserting a 410 nm cut-off filter significantly reduces the sample temperature and delays decomposition



410 nm filter, 10m on-sun

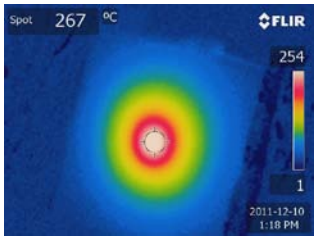
Reducing the UV flux greatly reduces the silicone temperature during on-sun testing

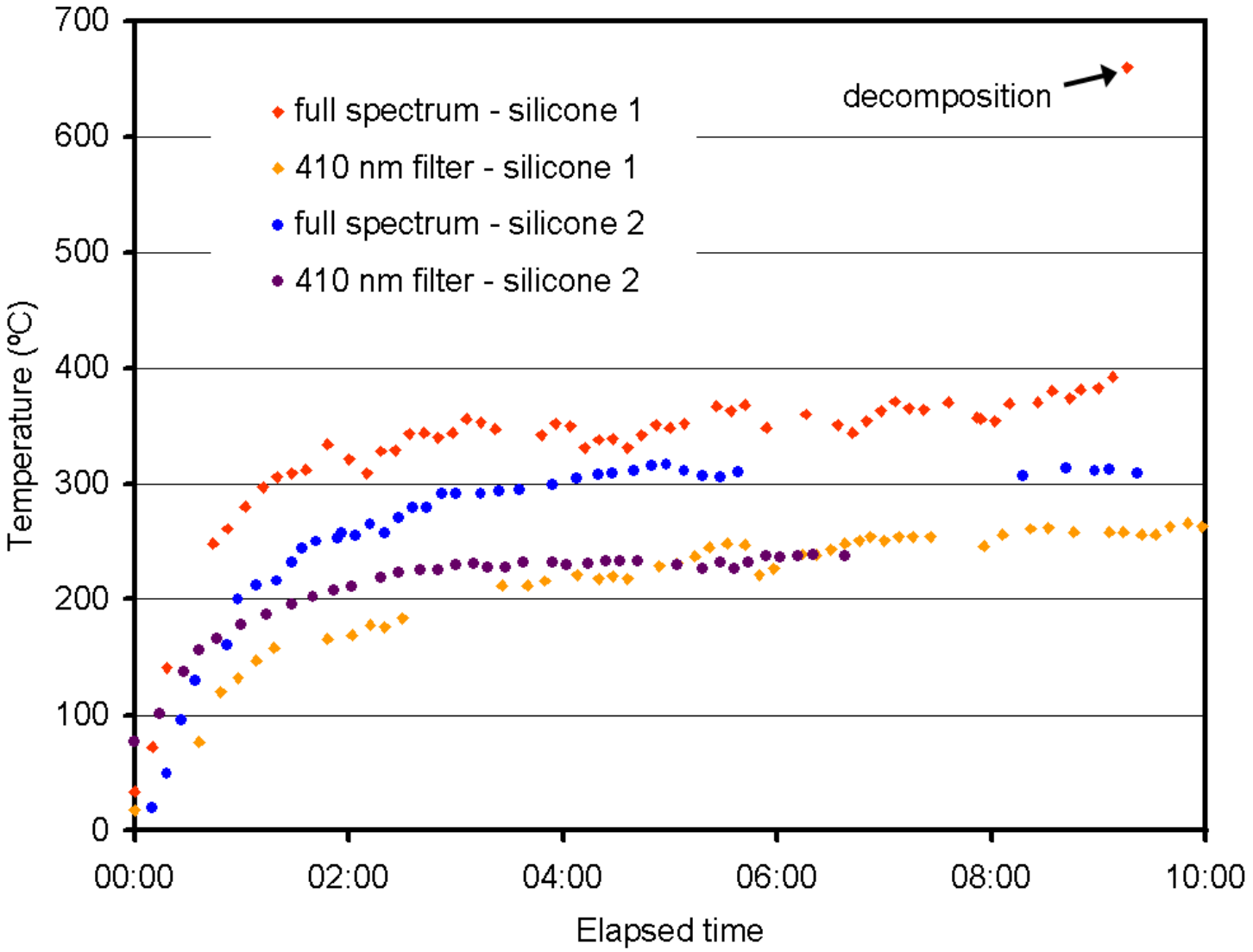




unfiltered

410 nm filtered



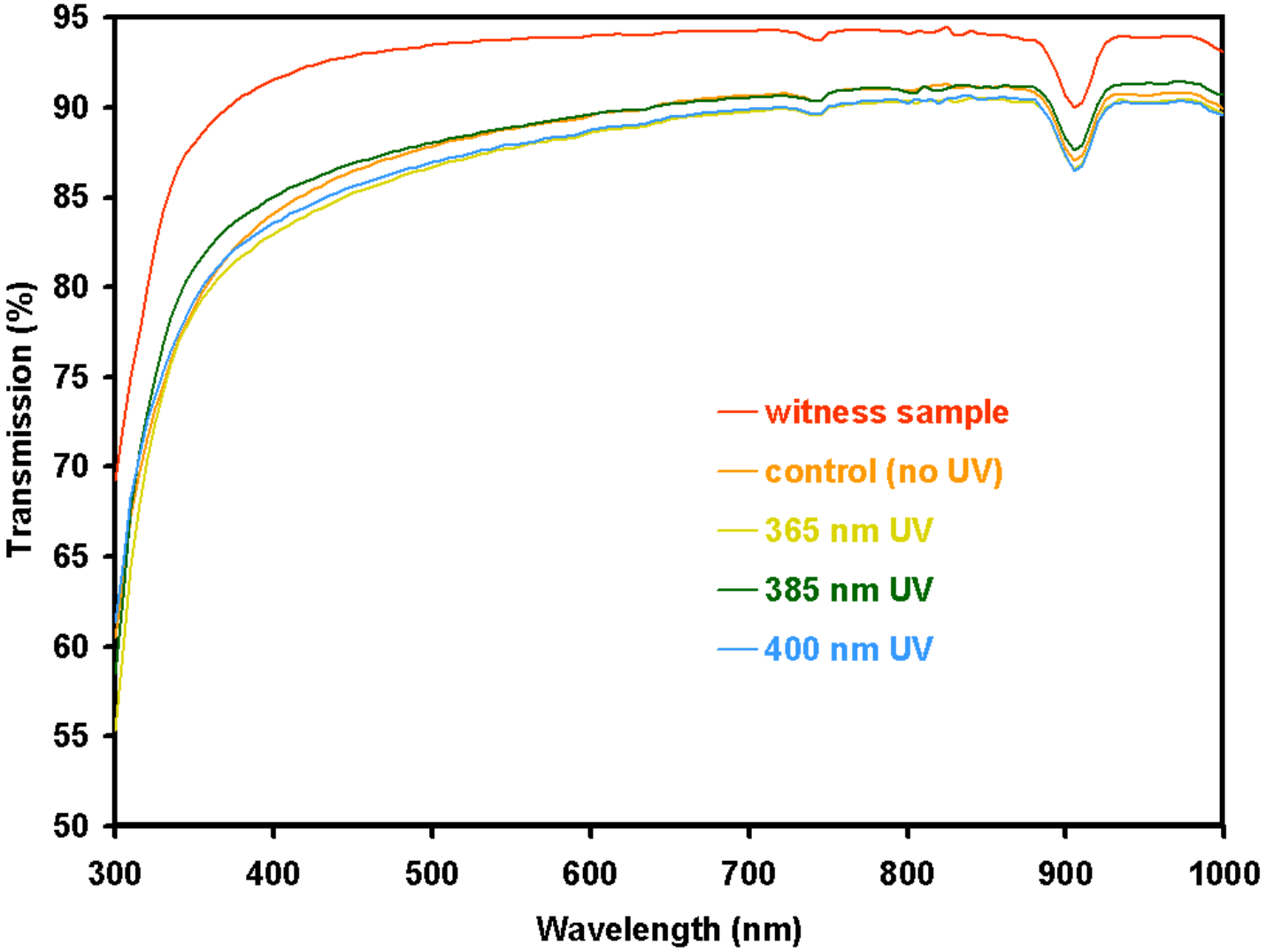


Removing UV wavelengths drastically increases time to decomposition

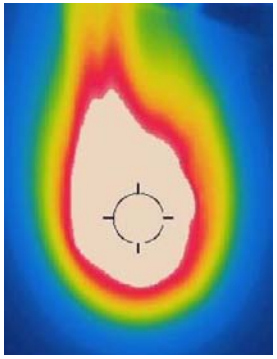
410 nm filter on the Fresnel with oil between

Time to decomposition		
Full spectrum (m)	410 nm filter (m)	Life Increase (%)
15-32	330	1500
4	30	750
47-52	390	780
4-22	120	850

Combined effects in the lab to determine acceleration factors



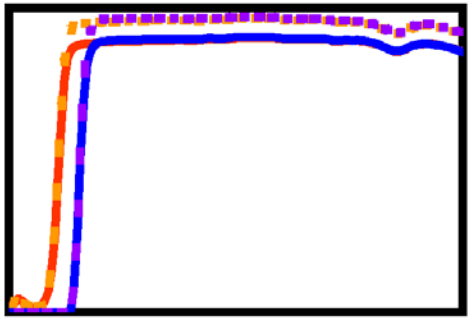
Establishing the reliability of polymers in a 1000X CPV system is a tricky business



accelerating a 1000X CPV system is not easy

a more sophisticated approach is needed to determine the lifetime of materials and interfaces of concern

elimination of UV appears to greatly enhance silicone longevity



knowledge of materials, interactions and kinetics of failure are essential to ensuring long term reliability