DOI: 10.1017/S1431927603442657
Microsc Microanal 9(Suppl 2), 2003

Improvements to Light Element X-Ray Windows for SiLi Detectors

M.C. Roberts*

*MOXTEK Inc., Orem, Utah 84057

Previously, the most prominent window for use on SiLi detectors for Scanning Electron Microscopes was MOXTEK's AP1.3 window. The AP1.3 window was constructed by combining a micromachined silicon support grid, two layers of ultrathin polymer, and two thin Al layers. Main failure causes of an AP1.3 window included cracked silicon structures, corrosion of the aluminum vapor barrier, and physical damage caused by an object contacting it. While physical damage can only be avoided by careful window handling, cracked silicon structures and corrosion were the main focus of improvement for a redesign. Considerations that were also made in the redesign were maintaining or improving the light rejection characteristics of the window and maintaining similar x-ray transmission (Fig. 1) in order to ensure that this window could be a drop-in replacement for the AP1.3 without any software modifications to new or existing instruments.

Each component of the AP1.3 window was analyzed and optimized for strength. The result is the new AP3.3. The new AP3.3 window has improved strength, corrosion resistance, and transmission over other light element detector windows. It consists of a micromachined silicon support grid, a single layer of ultrathin polymer (equivalent in thickness to the two layers of the AP1.3), and an Al layer and DuraCoat™ layer to provide a corrosion-resistant hermetic seal and to reject visible light.

Improvements were also made to all of the processing steps to make the ultrathin polymer film stronger, the silicon support grid stronger, and the bond between the two stronger. The Al evaporative coating method was also changed to eliminate pinhole leaks in the coating.

Changes in processing and design resulted in the following quantitative improvements.

Corrosion resistance was tested by gluing the windows into a mount in which the windows could be placed on a leak detector to determine a He leak rate through the windows. Three-AP1.3 and four-AP3.3 windows were determined to have a He leak less than $1X10^{-10}$ mbarL/sec. The windows were placed in a 100% humidity environment for 20 days. The He leak rate was measured every 2-3 days. At the conclusion of the testing all AP3.3 windows had a He leak rate of less than $3x10^{-10}$ mbarL/sec while the AP1.3 windows had a He leak rate greater than $1x10^{-9}$ mbarL/sec. In a corrosive environment, the AP3.3 windows clearly maintained the seal integrity better than the AP1.3.

Strength of the window and silicon support structure was measured by pressure cycling and then by burst testing the windows. A group of windows were, again, glued into mounts and leak tested. Six-AP1.3 windows and eleven-AP3.3 windows were pressure cycled placing 1.2 atm of pressure on the front side of the window. The pressure was applied for 6 seconds, off for 2 seconds and then repeated. None of the windows developed He leaks after 10,000 cycles. At 100,000 cycles all of the AP1.3 windows had developed He leaks and seven of the eleven AP3.3 had developed leaks. The AP3.3 windows demonstrated increased strength and durability over the AP1.3.

A separate group of windows were glued into mounts for burst testing. Four-AP1.3 and eight-AP3.3 windows were prepared. Burst testing involved applying a ramped pressure to the front of the window with the pressure ramped from 0 to 150 psi in 45 seconds. The pressures were recorded when the window burst and the test chamber lost pressure. Average burst pressure for the AP1.3 windows was 45 psi with the lowest measurement at 30 psi. Average burst pressure for the AP3.3 windows was 86 psi with the lowest measurement at 70 psi. The AP3.3 windows were clearly stronger than the AP1.3.

Changes were also made to the method of window assembly that facilitated a stronger bond between the silicon support structure and the polymer film. This bond strength was compared by burst testing the windows from the backside. The windows were prepared as for front pressure and then placed in the test chamber with the backside of the window facing the inside of the chamber. Four-AP1.3 and eight-AP3.3 windows were tested. The pressure was again ramped from 0 to 150 psi in 45 seconds. Average burst pressure for the AP1.3 windows was 27 psi with the lowest measurement at 15 psi. Average burst pressure for the AP3.3 windows was 85 psi with the lowest measurement at 55 psi. Again the AP3.3 windows were stronger and, remarkably, the back pressure was as strong as the front pressure strength.

Based on the changes made in the design of the window, it was anticipated that the He leak rate of the windows would improve, but the improvement was below our limits of detection. Since the release of the AP3.3, we have received confirmation that they have a He leak rate a magnitude lower than the AP1.3.

In conclusion, it was possible to improve the corrosion-resistance and strength of ultrathin polymer windows while maintaining excellent x-ray transmission and light rejection. All the testing performed on the AP3.3 windows concludes that it is more robust and capable of being a drop-in replacement for the AP1.3 window. Landmark improvements have been made in the reliability of ultrathin SiLi detector windows. [1]

References:

[1] This research was performed for MOXTEK, Inc. Members of MOXTEK's AP3.3 Design Team are gratefully acknowledged.

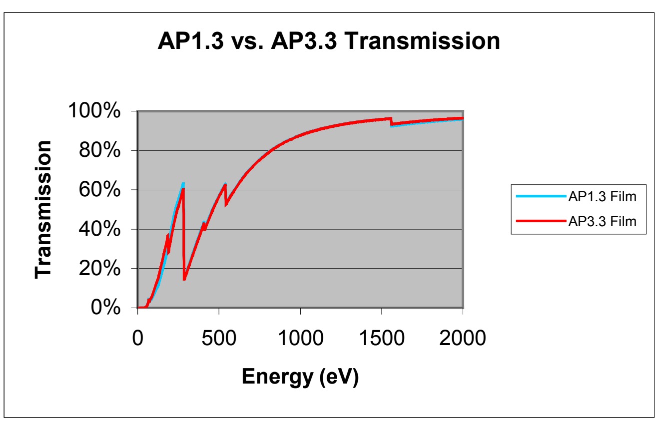

FIG. 1 Light element x-ray window transmission comparison.

https://doi.org/10.1017/S1431927603442657 Published online by Cambridge University Press