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An Improved Low Energy X-ray Transmission Window

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Introduction of new materials and designs have allowed production of an improved low energy X-ray transmission window. These changes have allowed improvement in the x-ray acceptance angle, the open area percentage and the x-ray transmission. The new window is built using low Z materials for the support structure and film. The x-ray window can tolerate well over 1 atmosphere of forward pressure. The window is shown to be resistant to corrosion from humidity and temperature. The window is high vacuum compatible and can tolerate vacuum bake out temperatures.

An X-ray window is an indispensable component for the X-ray detector. The window isolates the detectors vacuum environment from the sample's varying pressure environment (which in some applications can be at atmosphere) while allowing transmission of x-rays from the sample to detector. In addition to holding the pressure difference between the sample and detector without breaking, the window has to be gas impermeable, reject visible light, be charge disipating, and stable over time with exposure to many environmental variables. The materials used for the X-ray window should be low Z (atomic number) to maximize x-ray transmission through the window. The major challenge for the energy dispersive x-ray detector development is to increase the signal capture throughput per unit time. In this way, faster analysis can be achieved with the same amount of generated signal. In the case of the X-ray window, the goal is higher total active area of the window, allowing increased X-ray counts. However, larger areas result in higher total force differentials, which for existing materials would require design compromises to sustain without failure. With new materials and corresponding new designs, improvements can be made in not only total active area but several other properties that increase X-ray transmission such as ….

Figure 1A shows a cross section of the window structure with 1B showing the window and 1C an ANSYS model of the structure under load. The support structure of this new generation X-ray window is made from a strong low Z material with 3.6 GPa tensile strength and 46.7 GPa Young's modulus. The mechanical properties were measured by bending cantilevers, made of the same material, until failure. The force-displacement and eventual failure data was used to extract mechanical properties. ANSYS modeling of the window support structure was performed based on these mechanical results. New designs were explored and tuned within the ANSYS model to minimize stress and deflection under the expected load conditions.

The material for the support structure can also withstand high temperatures. According to thermogravimetric analysis (TGA) shown in Figure 2, the support structure material does not decompose until about 400 °C. Thus, a vacuum baking out process at 200°C can be performed with this new X-ray window.

In this new generation X-ray window, the thin transmissive film seen in figure 1A is coated with an ultra-thin passivation layer. A humidity test has been performed on the X-ray windows with and without this passivation layer under 50% relative humidity at 40 °C for 10 hours. The humidity protection is apparent from the optical images in figure 3. The X-ray window with the protection is still leak tight after the humidity testing.

The new strong materials enabled the design of a new support structure with reduced thickness and reduced width of the cross-window ribs. Changes in the film layers were also made. With these advantages, the X-ray acceptance angle has increased up from 53° to 72°, while the nominal open area percentage has increased from 76% to about 78%. Comparisons are made to currently available , similar application Moxtek windows.

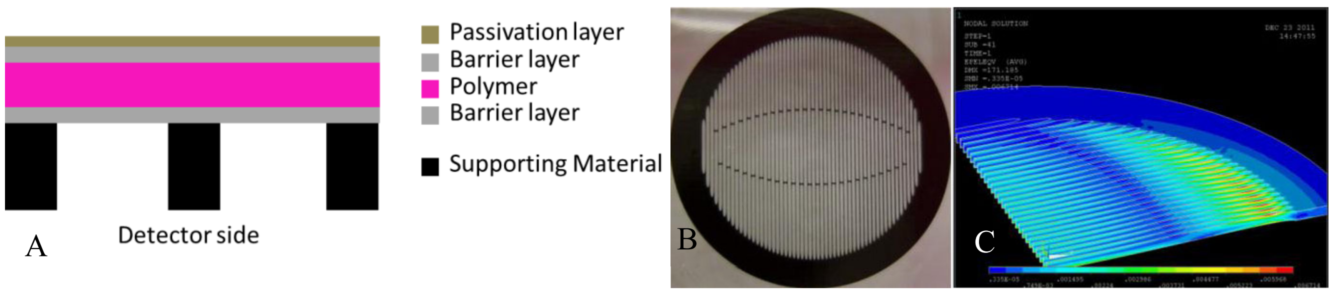

Fig. 1. A. Cross section diagram of the window structure, B. image of the new window support, and C. ANSYS model results of the window under load.

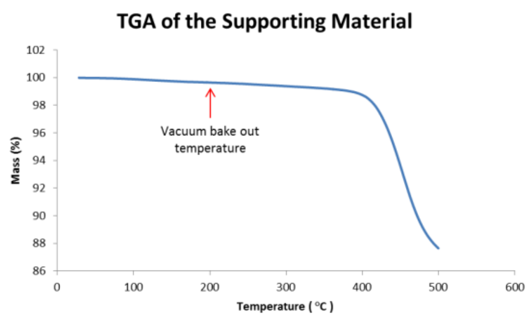

Fig. 2. Thermogravimetric analysis of the supporting material

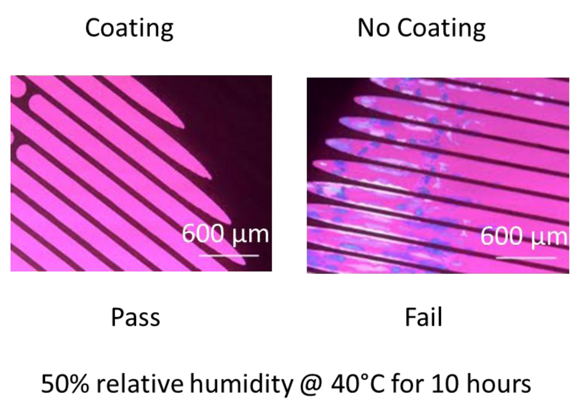

Fig. 3. Humidity testing on the window films with and without the passivation coating