



## Bismuth Passivation Technique for High-Resolution X-Ray Detectors

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The Athena-plus team requires X-ray sensors with energy resolution of better than one part in 3,000 at 6 keV X-rays. While bismuth is an excellent material for high X-ray stopping power and low heat capacity (for large signal when an X-ray is stopped by the absorber), oxidation of the bismuth surface can lead to electron traps and other effects that degrade the energy resolution. Bismuth oxide reduction and nitride passivation techniques analogous to those used in indium passivation are being applied in a new technique. The technique will enable improved energy resolution and resistance to aging in bismuth-absorber-coupled X-ray sensors.

Elemental bismuth is lithographically integrated into X-ray detector circuits. It encounters several steps where the Bi oxidizes. The technology discussed here will remove oxide from the surface of the Bi and replace it with nitridized surface. Removal of the native oxide and passivating to prevent the growth of the oxide will improve detector performance and insulate the detector against future degradation from oxide growth. Placing the Bi coated sensor in a vacuum system, a reduction chemistry in a plasma (nitrogen/hydrogen ( $N_2/H_2$ ) + argon) is used to remove the oxide and promote nitridization of the cleaned Bi surface. Once

passivated, the Bi will perform as a better X-ray thermalizer since energy will not be trapped in the bismuth oxides on the surface.

A simple additional step, which can be added at various stages of the current fabrication process, can then be applied to encapsulate the Bi film. After plasma passivation, the Bi can be capped with a non-diffusive layer of metal or dielectric. A non-superconducting layer is required such as tungsten or tungsten nitride ( $WN_x$ ).

*This work was done by James Chervenak and Larry Hess of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16383-1*