Advantages of Silicon Carbide Telescopes for Small-Satellite Imaging Applications

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1. Introduction

Optical Telescope Assemblies (OTAs) implemented in silicon carbide (SiC) provide performance advantages for space applications but have been predominately implemented in the government sector. A new generation of lightweight and thermally-stable designs is commercially available, expanding the application of SiC to small satellites. One of the major challenges in satellite telescope design is the ability to maintain performance in the thermal environment of low-earth orbits (LEO). Thermal stability analyses of two similar OTAs designed by AOS, one of SiC and one of Aluminum with Glass mirrors, are compared in this paper. The effect of temperature changes under soak conditions on ground resolved distance (GRD) are explored using image analysis.

2. Advantages of SiC

SiC possesses the highest combination of specific stiffness (E/p) and thermal stability (k/u) of any optical grade material. These properties make SiC ideal for maintaining optical and mechanical performance throughout launch and in the dynamic thermal environment of low-earth orbit (LEO).

3. SiC vs. Traditional Al-Glass Telescopes

Small satellite OTAs are typically required to meet optical performance specifications across a temperature range of approximately -30°C to +40°C for LEO applications. The analysis performed explores the impact to focus and GRD as a function of temperature. The telescope design used in the analysis is a two mirror, reflective system with a clear aperture of 125-mm designed to enable GRD ≤ 7.5-m for NIR wavelengths at an altitude of 500-km.

4. Impact of Thermal Soak on GRD

Figure 13: Ground resolved distance (GRD) versus temperature for SiC and Aluminum-Glass telescopes from -30 to +40°C.

5. Conclusion

• SiC system maintains the designed GRD over the typical required temperature range (±35°C).
• Aluminum-Glass system performance rapidly decays, even after ±2°C, from its optimal GRD.

The thermal properties of SiC allow for telescope systems that outperform Aluminum-Glass telescopes. In soak conditions, SiC focus shift is nominally zero. Furthermore, SiC shows up to 37x better performance across the temperature range for ground resolved distances over Aluminum-Glass telescopes in thermal soak conditions. Real-world scenarios present more complex challenges that reveal even more extensive benefits of optimized material selections.

6. References