Design and Development of Aerogel-Based Antennas for Aerospace Applications

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Purpose

The purpose of this project is to develop aerogels with properties tailored to enable new antenna concepts with performance characteristics (wide bandwidth and high gain) and material properties (mass, low density, environmental stability, and robustness) superior to the state of practice (SOP). Prototype antennas and arrays from down-selected aerogel formulations are being fabricated to benchmark against current antenna SOP. We will also explore ways of fabricating the antennas which both take advantage of the aerogel properties and overcome difficulties of using conventional lithographic techniques.

Background

The design and optimization of communication system technologies in support of aerospace platforms is of paramount interest in the aviation industry, for government (e.g., NASA, DoD, DHS, etc.) and the commercial sector. Among the key technologies are transmit/receive (Tx/Rx) antennas required for communications (voice, high data rate video, internet, etc.) and navigation (GPS). A typical commercial and/or military aircraft (e.g., Boeing 737) could have as many as 100 antenna systems. This large number not only adds weight to the aircraft but also increases the complexity, and challenges the structural integrity of the fuselage. The latter is exacerbated in general aviation aircraft (e.g., smaller Cessna type aircraft) due to the more limited space for antenna placement. ***Therefore approaches that could reduce the mass and number of antennas in these aircraft and any other pertinent airborne platform (e.g., long duration, high altitude elevation platforms) without sacrificing performance are highly coveted***. An innovative approach for lightweight antennas is to use aerogels which are highly porous solids with many interesting properties, including low density and low dielectric permittivity. The latter can reduce Radio Frequency (RF) losses and improve impedance matching and gain of the antenna. Furthermore, the physical dimensions of these materials could be tailored to increase relevant antenna parameters such as bandwidth.

Considering all these requirements, we selected Polyimide (PI) aerogels as candidate antenna materials in our Phase I study. PI aerogels have mechanical properties five hundred times better than silica aerogels, and can also be produced as thin films which are flexible and have good tensile properties. Phase I demonstrated that single PI aerogel patch antennas exhibit larger bandwidth, higher gain, and lower mass than their Duroid counterparts. The current technology readiness level (TRL) for the PI aerogel antennas is estimated to be 3 (the concept has been demonstrated in simple prototype antennas). In Phase II, we will develop antenna arrays incorporating robust PI aerogels developed at GRC to demonstrate lightweight antenna arrays with performance superior to that of SOP arrays, increasing TRL from 3 to 4.