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A NEW FABRICATION ROUTE FOR CERAMIC MEMS-BASED MICROPROPULSION SYSTEM - SOFT MOLDING TECHNIQUE USING SUBMICRON ALUMINA PARTICLES AND PRECERAMIC POLYMER

Abstract

A ceramic MEMS-based microthruster system was fabricated using a new fabrication route. The system consists of four major components: propellant reservoir, injector, electrodes and micronozzle, integrated into a single volume of 20mm X 20mm X 2mm. The smallest feature of the design is micronozzle throat with a dimension of 150 μm. The fabrication process starts with transferring the pattern of microthruster design into a polydimethylsiloxane (PDMS) soft mold using conventional lithography technique. A well-dispersed suspension of submicron alumina powder and polysiloxane preceramic resin was prepared and casted onto the soft mold. The dried green ceramic part was then sintered at a relatively low temperature of 1000 degree C to form Al2O3-SiO2 ceramic composite. Shrinkage of about 20% was noticed after sintering. Scanning electron microscopy (SEM) inspection reveals good shape retention on microstructures after the molding and sintering process. Thermal gravimetric analysis (TGA) verifies exceptional thermal properties of the ceramic composite as weight loss as small as 0.7wt% was observed even at temperature of 1000 degree C and flowing oxygen gas. Energy-dispersive X-ray spectroscopy (EDX) proves the formation of Al2O3-SiO2 composite as only elements of Al, O and Si were detected along with a negligible amount of residual carbon. The success in fabrication of microthruster system using ceramic composite is very beneficial for development of high performance liquid and solid propellant micropropulsion systems which require structural materials that able to operate under high temperature, oxidative and corrosive environment as a result of propellant combustion. In addition, the new fabrication route hold the promise for fabrication of microthruster system using different ceramic composites, such as SiC, SiCN, mullite, etc, allowing the designers to tailor suitable material properties according to different system requirements.