Power MEMS Materials and Structures

Personnel

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Sponsorship

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Material characterization, thermo-structural analysis, refractory ceramic microfabrication process development and packaging technology development are proceeding in support of several power MEMS programs including; the microengine, micro-rocket, micro-chemical power and microservohydraulic transducer projects. The potentially very high power density of these devices is predicated on the mechanical elements withstanding very high stress levels. In addition devices such as the microengine are designed to operate at high temperatures, and its performance is determined by the strength, creep and oxidation of its constituent materials. Since silicon and refractory ceramics are very brittle, and therefore variable, materials it is essential to obtain strength data from specimens which have been fabricated by the same process and at similar sizes to the intended application. Mechanical tests methods have been developed for probing the room temperature strength of microfabricated materials with particular emphasis on the local strength at stress concentrations and the relationship between strength and processing route. Probabilistic design calculations are being performed to translate the data obtained from test specimens to predict the strength of fabricated devices. Elevated temperature strength and creep data have been obtained for silicon in the operating temperature range of the microengine and microrocket. A unified creep/plasticity constitutive model has been developed and validated against independent test data.

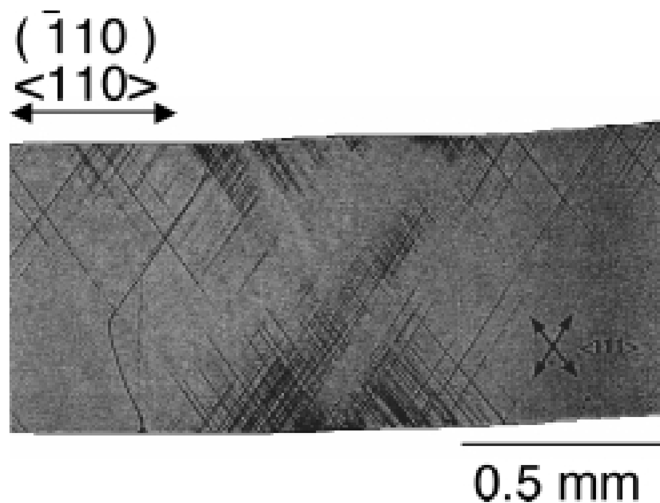

Fig. 21: Section of a silicon flexural creep specimens showing slip band structures.

Significant progress has been made in developing molding techniques with which to create hybrid Si/SiC structures by chemical vapor deposition of SiC into deep reactive ion etched silicon. Low residual stress SiC deposition has been achieved, and significant progress has been made on developing processes for planarization and wafer level bonding in order to create the hybrid structures.