PVDF Sensors for Dynamic Pressure Metrology in Extreme Environment
Capteurs PVDF pour la mesure de pression dynamique en environnement extrême

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Summary

High pressure range, extreme temperature and fast dynamic transient create an extreme environment for accurate pressure measurement. Military applications have a real need for dynamic pressure sensor in order to measure pressure in air blast experiments. Such experiment is a typical extreme pressure measurement application with high temperature and pressure and fast dynamic transient [1]. Structure vulnerability and explosive optimisation need accurate experimental value to improve the accuracy of numerical models [2]. Most of known pressure sensors present a full-scale pressure measurement and bandwidth that are not sufficient for sensing fast pressure variation with high amplitude. The high cut-off frequency of these sensors creates highly undesirable harmonics distortion on the signal and a low (microsecond) rise time.

This communication proposes the model and the design of dynamic pressure sensor with nanosecond rise time working in the GPa range in extreme temperature conditions. Based on well-known piezoelectric polymer technologies PVDF [3], key issues related to these sensors such as the packaging, impact of cables and role of the conditioning electronic are addressed in this communication. Based on acoustic/electrical equations analogies [4] the circuit model implementable in Spice software is reported for simulating the sensor response for different excitations such as pulse, unit step or sine function. Thermal protection layers, backing materials, measurement cables and conditioning electronics are taking into account in the sensor simulation and their impacts on the sensor performances are discussed. Moreover the bandwidth, rise time and sensitivity are derived from the proposed simulation model and design rules are given.

Finally a PolyVinylidene DiFluoride (PVDF) sensor prototype is presented and shock tube experiment is described [5]. Different shock wave amplitude with nanosecond rise time has been recorded by the designed sensor and rise time, bandwidth and sensitivity have been measured and compared with ones provided by various commercial pressure sensors. The proposed sensor has been calibrated with this shock tube method. Dynamic uncertainties of the sensor have been evaluated based on the work of the EURAMET project [6].

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