DREAMSys MEMS Microphone specifications

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Date of release	30th November 2007
Project:	DREAMSys
DIIS number	QINETIQ/EMEA/S&DU/TS0709002

Introduction

The aim of this report is to present the target specification for the first generation of prototype MEMS microphones for use in the acoustic sensor nodes being developed as part of the DREAMSys programme. This specification has been set to meet the needs of environmental noise mapping applications.

Target Specification.

The key specifications for MEMS microphones for use in the DREAMSys environmental noise measurements are presented below in table 1. The key targets are minimum detectable sound pressure level; where 40 dB(A) is seen as being workable and 20 dB(A) is seen as ideal; acoustic frequency range from 20Hz to 20kHz and dynamic range of 70 dB. It is also seen as being desirable to have a temperature measurement of better than 1°C. One

Acoustic dynamic range	70 dB
Minimum detectable sound pressure level	40 dB(A) could be workable 30 dB(A) would be useful 20 dB(A) would be ideal
Maximum detectable sound pressure level	110 dB_A
Acoustic frequency range	20 Hz to 20 kHz
Mechanical membrane resonant frequency	>30 kHz
On-chip temperature measurement accuracy	<1°C
Operating voltage	3.3V
Operating current	few mA
Analogue voltage range	~1V
Size of PCB assembly	<10mm x <10mm
Shape of PCB	Optimised to avoid diffraction effects

Table 1 – Target specification for MEMS microphones for use in DREAMSys environmental noise measurement sensor nodes.

of the benefits of having such a sensor is that it will enable temperature compensation of the MEMS microphone should it be required.

Route to achieving required specification.

The key design parameters that define the acoustic performance of a MEMS microphone are illustrated in figure 1. These are the acoustic membrane radius R, membrane thickness t and the plate separation h and the acoustic volume enclosed within the microphone package. The residual stress in the acoustic membrane resulting from the fabrication process also plays and important role. All of these design parameters have been included in an analytical model that has been developed to describe the electro-acoustic behaviour of MEMS microphones and to help in the design of said devices.

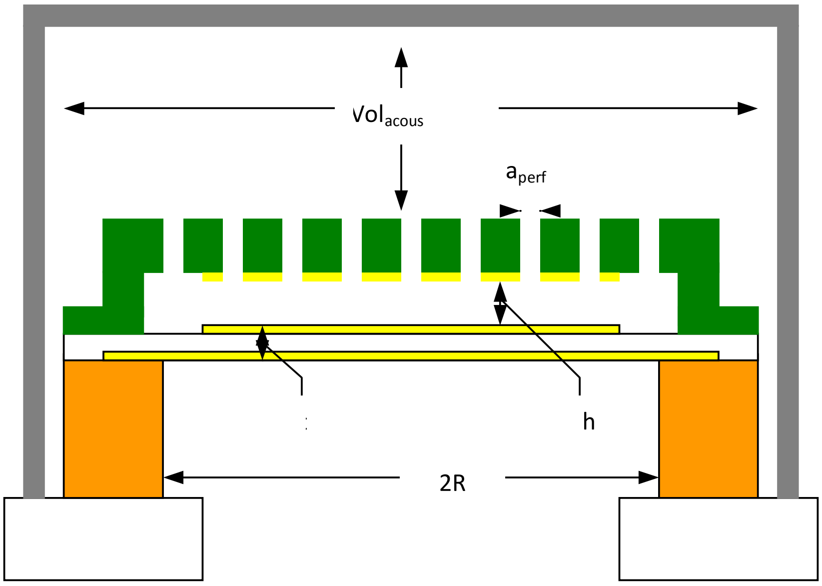

Figure 1 – Key geometric features of package MEMS microphone that define acoustic performance.

MEMS microphones based on QinetiQ's low temperature metal-nitride surface micromachining process have been designed and fabricated. These have a nominal plate separation and membrane thickness of 1.2µm and 1.4µm respectively and membrane radii of 1, 1.25 and 1.5µm. The nominal in built stress in the acoustic membrane of these devices is 20MPa.

Based on capacitance voltage measurements to determine the static mechanical response of these devices and analytical models of the acoustic performance of these microphones the most appropriate candidate to meets the requirements outlined in table 1 will be identified and packaged in a suitable form for acoustic assessment at NPL. The performance of these devices will be assessed prior to a second design and device fabrication iteration to meet the needs of the final demonstrator devices due to be delivered in the summer of 2008.

The role of the package is an important factor in determining the ultimate acoustic response of these microphones. Previous MEMS microphones fabricated at QinetiQ and assessed at NPL have shown an increase in sensitivity of >1dB for frequencies above approximately

4.5kHz. This has been attributed to reflection/ diffraction effects abound the PCB on which the microphone is mounted. To try to ameliorate these effects a routes to realising a suitable package with a smaller acoustic footprint are being developed. Whilst wafer level packing techniques which may ultimately result in the smallest possible microphone embodiment of a MEMS microphone are being developed at QinetiQ the process required to realise these will not be ready in time to meet the timescales required for the delivery of the first set of devices which are due to be delivered to NPL in January 2008. As a consequence a second interim route based on the use of ceramic substrate and a micro-formed lid is proposed. This package concept is shown schematically in figure 2. The proposed width of this implementation is 7mm. This is less that half the width of the previous PCB implementation and should enable the delivery of a flat, direction independent, response for frequencies up approximately 10kHz.

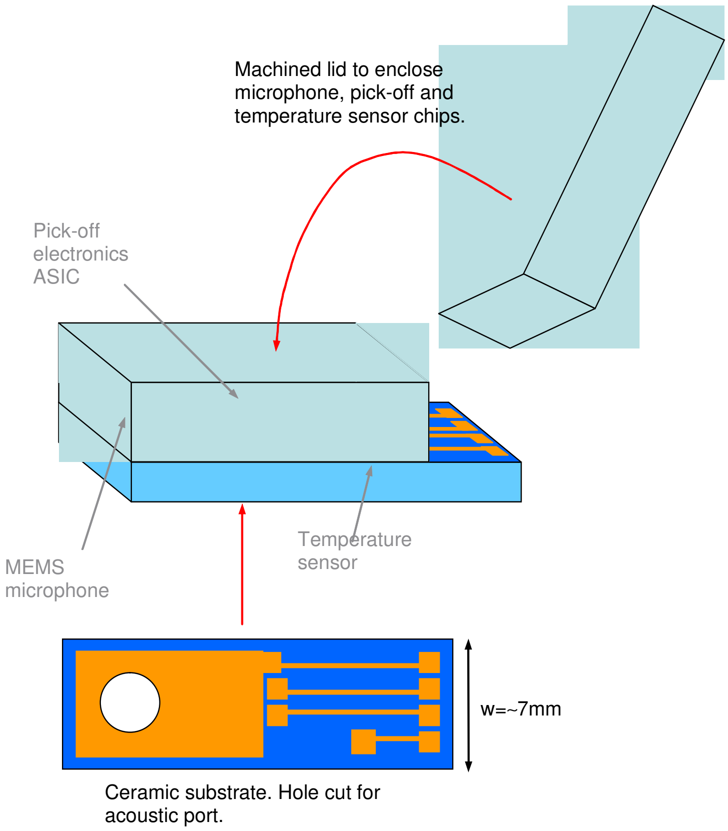

Figure 2 – Schematic showing concept packaging for 1st generation DREAMSys microphone.

Using a COTS temperature sensor (a National Semiconductor LM61 in an SOT-23) package the footprint of the ceramic is expected to be approximately 7×21mm^2 including all of the associated passive components. Although larger that the target size of 1cm^2 a smaller embodiment should be achievable one wafer level packaging is available. Moving the temperature sensor off the ceramic would also enable a significant reduction in size.

The target operating voltage for the sensor node is 3.3V. However it should be noted that previous characterisation of MEMS microphones designed and fabricated by QinetiQ has been undertaken using a supply voltage of 5V. Although all of the circuit elements used will function correctly with a 3.3V supply voltage the microphone sensitivity, which is directly proportional to the bias voltage applied across it, will be reduced commensurately. This will have a knock on effect on the minimum detectable SPL that can be measured with the microphone. If necessary this could be mitigated by using a 5V supply voltage on the microphone board and ac coupling in the output from the microphone into the following data logging electronics that will be operated at 3.3V.

Conclusion

The target specification for a MEMS microphone for use in the DREAMSys programme and outline plan for how this will be achieved have been presented. Measurements of the acoustic performance of these devices will inform a second design and fabrication iteration which will be undertaken in the summer of 2008 and will deliver the final devices for assessment in sensor nodes by Hoare Lea.