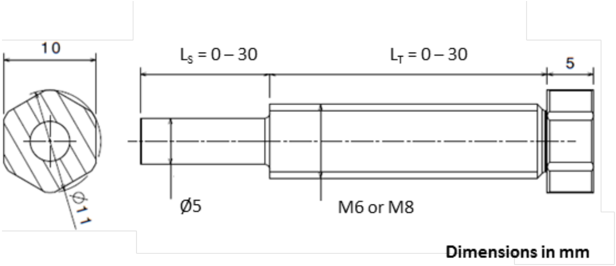
Models CMA-1A, -3A, -1R, -3R
Fast Response Pressure Sensors

- Encapsulated absolute & relative pressure die
- High measurement bandwidth
- Media: Air, Water, Steam
- Robust packaging for high temperature
- Threaded or smooth casing

The CMA sensor assembly serie offers a very versatile range of pakaged pressure sensors designed for measuring dynamic pressure either in air, water, steam.

The sensor assemblies consist of absolute or relative pressure die mounted onto smooth or threaded casings. The sensors are coated with hydrophobic RTV ensuring their operation in water and steam. For harsh operating condition such as particle laden flows, . The pakaged sensors are available for the most stringent applications requiering either high pressure sensitivity or operation up to 220°C. If required the sensors can be also equipped of protective perforated screen for



The pressure transducers can be either operated in a constant current or constant voltage mode. They are delivered fully calibrated with integrated temperature compensation, if requested. LSc also provide electronics for signal conditioning and current supply, please refer to the wireless multi-sensor measurement system product. The sensors will be delivered calibrated with the on-board electronics, and a set of polynomial calibration coefficient will be provided to be used with LSc's monitoring software.

Fast Response Pressure Sensors
Models CMA-01-R, CMA-10-R-HT, CMA-35-A

Specifications

All specifications assume a 1mA excitation voltage unless otherwise stated.

Characteristics	Units	CMA-01-R	CMA-10-R-HT	CMA-35-A
Sensor type		relative	relative	absolute
Pressure range	bar	0 – 0.1	0 - 1	0 - 3
Temperature range: Operation / Calibration	°C	-50 to 120°C / 5°C to 120°C	-50 to 220°C / 5°C to 220°C	-50 to 120°C / 5°C to 120°C
Measurement bandwidth **1. RTV coated** **2. Protective perforated screen**	kHz	1. 140 2. 50	1. 140 2. 50	1. 140 2. 50
Sensitivity @ 25°C	mV/bar	1000	43	10
Burst pressure (diaphragm)	bar	6	20	10
Non-Linearity	%FSO	±0.5	±0.2	±0.3
Bridge resitance	Ω	3500	3400	2800
Electrical supply constant voltage or current mode	V /mA	5 / 1	5 / 1	5 / 1
Media compatibility **1. RTV coated** **2. Protective perforated screen**		1. air, water steam 2. air	1. air, water steam 2. air	1. air, water steam 2. air
Case material		Stainless steel	Stainless steel	Stainless steel
Smooth casing length (L_S)	mm	Up to 50	up to 50	Up to 30
Threaded casing length (L_T)	mm	up to 50	Up to 30	Up to 30
Thread dimensions	Metric UNC	M6 or M8 1/4-20 or 5/16-18	M6 or M8 1/4-20 or 5/16-18	M6 or M8 1/4-20 or 5/16-18

High temperature fast response pressure probe for use in liquid metal droplet dispensers

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A miniature fast response high temperature pressure probe, with demonstrated use in liquid metals up to 255 °C (528 K), has been developed. Innovative packaging technologies have been applied to integrate a conventional piezoresistive silicon pressure sensor into the probe, without the need of an auxiliary water-cooling system. *In situ* static calibrations are used to verify the linearity of the pressure signal and the stability of the pressure sensitivity (0.5% standard deviation over 70 min at 255 °C). Dynamic calibration, completed in an air shock tube facility, yields the probe's natural frequency. This frequency, when corrected for probe operation in liquid tin, is found to be 100 kHz. The reliability and accuracy of the probe is assessed by mounting it in a tin droplet dispenser for use in an extreme ultraviolet light source. Droplet dispensers typically include an excitation mechanism, which can be based on the generation of acoustic pressure waves to impose a desired droplet frequency. The probe accuracy is verified by the comparison of pressure measurements with laser Doppler vibrometry measurements of the pressure generating structure. A reference pressure measurement, conducted at representative conditions, shows a complex frequency response, with peaks distributed over three orders of magnitude and maximum amplitude of 440 mbar. Time variance of the excitation mechanism due to thermal transients is studied by monitoring the pressure response during operation. Finally, the linearity of the excitation system, with respect to the excitation amplitude, is verified by response measurements. In conclusion, the developed probe is capable of characterizing the excitation mechanism of a liquid metal droplet dispenser. Additionally, real-time monitoring of the performance of the excitation system during long-term operation is possible. [http://dx.doi.org/10.1063/1.4730046]

I. INTRODUCTION

Liquid metal droplet generators are of common interest in different technical areas. Typical applications are found in micromanufacturing[1–3] and circuit board printing.[4–6] The background of the present work is droplet generation for use in extreme ultraviolet (EUV) lithography, which is the successor technology of the current 193 nm lithography used for manufacturing semiconductor devices.[7] EUV lithography is based on 13.5 nm radiation, thereby enabling printing of feature sizes below 20 nm. Droplet dispensers are a key component of EUV light sources, in which a tin droplet is irradiated by a high power and high repetition rate (greater than 10 kHz[8]) laser to create a laser produced plasma, which emits in the EUV wavelength bandwidth.[9–11] A key challenge in EUV lithography is source power and stability,[12] which correlates with the performance of the droplet generator.

Droplets can be either generated in a discrete way by employing droplet-on-demand techniques,[13,14] or in a continuous way by relying on the capillary breakup of a jet.[15–17] In both cases, an excitation mechanism, which introduces a flow disturbance, is required to impose the desired droplet frequency.[18] Different implementations, typically based on piezoelectric transducers, have been developed.[19–22] In the present work, a piezoelectrically actuated oscillating piston generates acoustic pressure waves at the nozzle inlet, as shown in Fig. 1. While droplet formation itself has been extensively studied over the last decades, the non-ideal boundary conditions of droplet formation due to disturbance dynamics have not been investigated for liquid metal dispensers. Time-resolved pressure measurements at the position of the nozzle are highly desirable. To date, a piezoelectric pressure transducer has only been used in the vicinity of a dispenser nozzle at room temperature, for monitoring the pressure disturbance induced by an amplitude-modulated excitation source.[23]

In this work, the technology of a fast response (greater than 10 kHz) and high temperature (up to 255 °C) pressure probe, which is based on a miniature piezoresistive silicon pressure sensor, is demonstrated. Probe design is derived from the fast response aerodynamic probe (FRAP) technology from ETH Zurich, which has been extensively utilized in the past decades for aerodynamic measurements in turbomachinery flow fields.[24,25] The high temperature version of the FRAP probe has been developed by Lenherr *et al.*[26] Other state-of-the-art high temperature pressure probes are based on silicon-on-insulator[27] sensors, which are, however, not commercially available for the required size. Another probe type relies on water-cooled piezoresistive sensors,[28] which have the severe disadvantage of cooling the liquid in contact with the sensor.

A major requirement is long-term reliability of the probe in the harsh environment of a liquid metal droplet dispenser. The probe is either used for studying disturbance dynamics in the dispenser development phase or for monitoring the performance of the excitation system during long-term operation.

