Heat flux measurement in an internal combustion engine with a metal substrate MEMS sensor

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An original thin film resistance sensor was developed by using the MEMS technology for heat flux measurement in an internal combustion engine under a national project, SIP [1]. Fig. 1 and Fig. 2 show the heat flux sensor and the layer structure of it, respectively. The sensor is constructed of Al_2O_3 insulation layer, Pt sensing layer and Al_2O_3 passivation layer on the Al alloy substrate. Since Al_2O_3 has about 40 % thermal expansion coefficient of that of Al alloy, it is used for the insulation and passivation layers in order to prevent the sensor from breaking caused by high temperature environment in the engine. The temporal resolution of the sensor is the order of 100 kHz, and the sensor is driven under a constant current mode which has the cut-off frequency of 10 kHz. Therefore, the total responsiveness of this measurement system is 10 kHz. The sensor has three thin film resistance temperature detectors (RTD) of a square 315 μm on a side on 900 μm diameter circle in rotational symmetry. These RTDs measure the wall surface temperatures, and the instantaneous wall heat fluxes are calculated through transient conduction analysis with boundary conditions given by the surface temperature measurement. Detailed heat flux measurement in the engine was difficult on account of the lack of resolution of conventional sensors, and the turbulent heat transfer mechanism in the engine has not be clarified yet. On the other hand, our sensor has high spatial and temporal resolution, and the fluctuation or disturbance of combustion flame can be detected. Therefore, the sensor may become a powerful tool for the investigation of the heat transfer mechanism. In the seminar, we will report the result of the measurement test in an internal combustion engine.

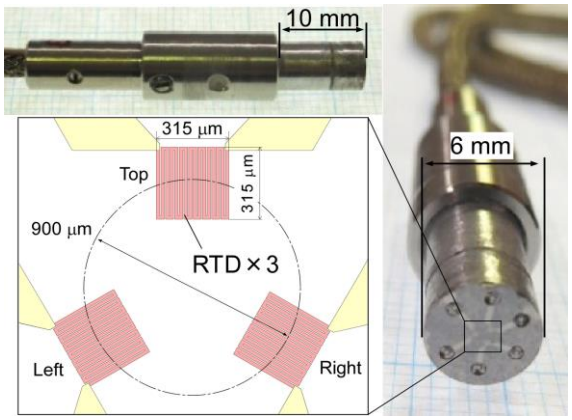

Fig. 1: MEMS three points heat flux sensor.

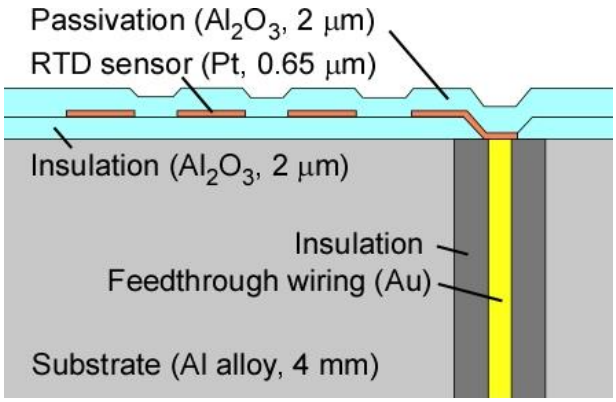

Fig. 2: Layer structure of the MEMS sensor.

[1] Cabinet Office, Government of Japan, Cross-ministerial Strategic Innovation Promotion Program, http://www8.cao.go.jp/cstp/gaiyo/sip/ (accessed on July 26, 2017).