CAPE Grand Challenge: Photonics and Electronics 2022

Topic 1: MEMS and micromachined silicon structures

1. Capacitive Micromachined Ultrasonic Transducer(CMUT)

Project Elements

(1) CMUT monomer and array structure design;
(2) CMUT vibration model simulation, electromechanical coupling simulation, array element parameter design and simulation;
(3) CMUT process design;
(4) CMUT area array transceiver performance test;

Requirement: The number of array elements is not less than 16×16, the operating frequency is not less than 2MHz, and the relative bandwidth of -6dB is not less than 80% of the operating frequency.

2. Silicon-based MEMS Vibration Sensor Technology

Project Elements

(1) The structure design of MEMS Vibration Sensor
(2) The process design of MEMS Vibration Sensor
(3) Design of Low Noise Signal Detection Circuit

Requirement: The frequency response range is 1-2000Hz; the acceleration measurement range is 50g, and the zero bias temperature coefficient is 5μg/℃ (-45℃~+85℃)

3. Silicon-Based Microfluidic Heat Sink

Project elements

(1) Multi-layer bifurcated structure micro-channel radiator design;
(2) Simulation analysis of liquid flow channel characteristics in microchannels;
(3) Research on liquid phase transition and heat dissipation characteristics in microchannels;
(4) The influence of micro-channel structure and surface roughness on the liquid flow characteristics and heat transfer characteristics;

Requirement: Under the condition that the fluid flow rate is 5m/s, the temperature of the hot spot does not rise more than 50℃, and the maximum heat flux density of the hot spot that the radiator can cool is not less than 150W/cm^2.

4. Getter technology for MEMS vacuum packaging

Project elements

(1) Carry out research on the preparation process of vacuum encapsulated getter materials;
(2) Characterization of getter material, getter rate test;
(3) Residual gas analysis in vacuum packaging chamber for packaged MEMS devices;;

Requirement The suction rate is not less than 200cm^3/s/cm^2, the suction volume in 2h is not less than 100Pa·cm3/cm2, and the vacuum degree of vacuum packaging is better than 1Pa.

5. High Precision Silicon-based MEMS Oscillator Technology

Project Elements

(1) Carry out research on the full temperature (-45℃~85℃) drift and frequency compensation technology of silicon-based MEMS oscillators;
(2) Carry out the corresponding high-precision, low-noise oscillator detection circuit design

Requirements:

(1) The frequency stability of the oscillator at room temperature is better than 10ppm (1h, 1σ);
(2) The Q value of the silicon-based MEMS oscillator after vacuum packaging for open-loop testing is better than 200,000;
(3) The frequency stability after oscillator compensation is controlled within ±20ppm

6. Design Technology of High Quality-Factor Silicon Based Capacitive Resonant Structure

Project elements

(1) Analysis of the damping loss mechanism of capacitive resonant structures (such as different forms of beam structures and double-ended fixed tuning fork structures) under different package vacuum degrees, and propose corresponding suppression methods to realize the design of high quality factor capacitive resonant structures;
(2) Mechanism analysis of nonlinear vibration error source in capacitive resonant structures (beam structure, double-ended fixed tuning fork structure), and proposed structure optimization design scheme.
(3) Full-temperature frequency stability of capacitive resonant structures (folded beams, double-ended fixed beams, etc.).

7. Mechanism study on the effect of impedance of the output characteristics of silicon-based MEMS capacitive sensors

Project elements

(1) The influence mechanism and suppression method of different impedances (≤500

MΩ, 500, MΩ ~1 GΩ, ≥1 GΩ) on the output characteristics of silicon-based capacitive sensors.