Butterfly Network has developed a large Capacitive Micromachined Ultrasonic Transducer (CMUT) die, intended to be integrated into a handheld medical ultrasound. Known as the iQ, it is based on semiconductor technology and is manufactured by a semiconductor supply chain. This solution reduces manufacturing cost and produces very small CMUT elements.

The Butterfly Network CMUT die is a phased array transducer, a large matrix of 8,960 transducers, in a 140 x 64 arrangement. They emit the ultrasonic signal and receive the echo as acoustic waves. The large matrix of 8,960 transducers and the large Application Specific Integrated Circuit (ASIC) die enable an efficient 2D phased array sensor. Thanks to the miniaturization of the CMUT, one probe can do curved, linear and phased analyzes. In other cases with conventional equipment three different probes are necessary to enable the same procedures.

The CMUT cells are manufactured with MEMS technology in silicon. Bulk and thin-film micromachining technologies are used to form the electrodes and the cavity. The secret of the first semiconductor CMUT is not only in the MEMS die but also in the integration with the ASIC die. The ASIC die has all the functions to drive pulse generation, measure the echo, run Butterfly Network’s algorithms and communicate with the processor on the printed circuit board (PCB). Each CMUT is driven by a block with CMOS logic, analog reading circuit and LDMOS transistors for the emission. The ASIC die and the CMUT die are bonded together at wafer-level and a part of the process is common for the two wafers after the bonding for through silicon via (TSV) connection.

This report is focused on the analysis of the CMUT semiconductor. It includes an ultrasonic MEMS transducer and the ASIC die developed by Butterfly Network. Some pictures of the disassembly of the iQ probe are displayed in the report.

Along with the complete ultrasonic CMUT MEMS teardown, this report analyzes die cost.
TABLE OF CONTENTS

Overview/Introduction

Physical Analysis
- Summary of the Physical Analysis
- Company Profile
  - Butterfly
  - Butterfly iQ
- Physical Analysis
  - Module views
  - Module cross-section
- CMUT Die
  - CMUT die views and dimensions
  - CMUT die process
  - CMUT die cross-section
  - CMUT die process characteristics
- ASIC Die
  - CMUT die views and dimensions

Cost Analysis
- CMUT and ASIC Die Fabrication Unit
- Probe Test Unit
- Yield Explanations and Hypotheses
- ASIC Wafer Cost
  - Wafer and die cost
- CMUT Die Cost
  - CMUT die front-end cost
  - CMUT die probe test, thinning and dicing
  - CMUT die wafer cost
- Complete Die Cost
  - Summary of the assembly
  - CMUT die cost

Manufacturing Process
- ASIC Die Front-End Process
- CMUT Die Front-End Process

AUTHORS

Sylvain Hallereau has been Project Manager at System Plus Consulting since 2000. He is in charge of costing analyses for Integrated Circuits, Power semiconductors and LEDs. He has significant experience in the modeling of manufacturing costs for electronics components.

Véronique Le Troadec has joined System Plus Consulting as a laboratory engineer. Coming from Atmel Nantes, she has extensive knowledge in failure analysis of components and in deprocessing of integrated circuits.

RELATED REPORTS

TDK-Chirp Ultrasonic Time of Flight Sensor
The first Piezoelectric Micromachined Ultra-sonic Transducer (PMUT) millimeter-accurate ultra-low power Time of Flight sensor.
February 2020 - EUR 3,990*

USound Acheulous UT-P 2016 MEMS Speaker
First mass-produced MEMS speaker based on SOI and PZT thin film technology.
October 2019 - EUR 3,990*

Piezoelectric Material From Bulk to Thin Film – Comparison 2019
Unique technical and cost review of 16 piezoelectric modules from market pioneers, including transducers, inkjet dies, MEMS gyroscopes, RF filters, MEMS microphones and micro-speakers.
September 2019 - EUR 6,490*
REVERSE COSTING® – STRUCTURE, PROCESS & COST REPORT

COSTING TOOLS

Our analysis is performed with our costing tools MEMS CoSim+ and IC Price+

System Plus Consulting offers powerful costing tools to evaluate any process or device, the production cost and selling price, from single chip to complex structures. All these tools are on sale under corporate license.

IC Price+
The tool performs the necessary cost simulation of any Integrated Circuit: ASICs, microcontrollers, memories, DSP, smartpower...

MEMS CoSim+
Cost simulation tool to evaluate the cost of any MEMS process or device.

WHAT IS A REVERSE COSTING®?

Reverse Costing® is the process of disassembling a device (or a system) in order to identify its technology and calculate its manufacturing cost, using in-house models and tools.

CONTACTS

System Plus Consulting is specialized in the cost analysis of electronics from semiconductor devices to electronic systems.

A complete range of services and costing tools to provide in-depth production cost studies and to estimate the objective selling price of a product is available.

Our services:
- STRUCTURE & PROCESS ANALYSSES
- TEARDOWNS
- CUSTOM ANALYSES
- COSTING SERVICES
- COSTING TOOLS
- TRAININGS

www.systemplus.fr
sales@systemplus.fr

America Sales Office
Steven LAFERRIERE
Western USA & Canada
+1 310-600-8267
lafriere@yole.fr
Chris YOUMAN
Eastern USA & Canada
+1 919-607-9839
chris.youman@yole.fr

Asia Sales Office
Takashi ONOZAWA
Japan & Rest of Asia
+81 80 4371 4887
onozawa@yole.fr
Mavis WANG
Greater China
TW +886 979 336 809
CN +8613661566824
wang@yole.fr
Peter OK
Korea
+82 10 4089 0233
peter.ok@yole.fr

Headquarters
22, bd Benoni Goullin
Nantes Biotech
44200 Nantes
France
+33 2 40 18 09 16
sales@systemplus.fr

Europe Sales Office
Lizzie LEVENEZ
Frankfurt am Main
Germany
+49 151 23 54 41 82
llevenez@systemplus.fr
1. INTRODUCTION
The present terms and conditions apply to the offers, sales and deliveries of services managed by System Plus Consulting except in the case of a particular written agreement.
Buyer must note that placing an order means an agreement without any restriction with these terms and conditions.

2. PRICES
Prices of the purchased services are those which are in force on the date the order is placed. Prices are in Euros and worked out without taxes. Consequently, the taxes and possible added costs agreed when the order is placed will be charged on these initial prices.
System Plus Consulting may change its prices whenever the company thinks it necessary. However, the company commits itself in invoicing at the prices in force on the date the order is placed.

3. REBATES and DISCOUNTS
The quoted prices already include the rebates and discounts that System Plus Consulting could have granted according to the number of orders placed by the Buyer, or other specific conditions. No discount is granted in case of early payment.

4. TERMS OF PAYMENT
System Plus Consulting delivered services are to be paid within 30 days end of month by bank transfer except in the case of a particular written agreement.
If the payment does not reach System Plus Consulting on the deadline, the Buyer has to pay System Plus Consulting a penalty for late payment the amount of which is three times the legal interest rate. The legal interest rate is the current one on the delivery date. This penalty is worked out on the unpaid invoice amount, starting from the invoice deadline. This penalty is sent without previous notice.
When payment terms are over 30 days end of month, the Buyer has to pay a deposit which amount is 10% of the total invoice amount when placing his order.

5. OWNERSHIP
System Plus Consulting remains sole owner of the delivered services until total payment of the invoice.

6. DELIVERIES
The delivery schedule on the purchase order is given for information only and cannot be strictly guaranteed. Consequently any reasonable delay in the delivery of services will not allow the buyer to claim for damages or to cancel the order.

7. ENTRUSTED GOODS SHIPMENT
The transport costs and risks are fully born by the Buyer. Should the customer wish to ensure the goods against lost or damage on the base of their real value, he must imperatively point it out to System Plus Consulting when the shipment takes place. Without any specific requirement, insurance terms for the return of goods will be the carrier current ones (reimbursement based on good weight instead of the real value).

8. FORCE MAJEURE
System Plus Consulting responsibility will not be involved in non execution or late delivery of one of its duties described in the current terms and conditions if these are the result of a force majeure case. Therefore, the force majeure includes all external event unpredictable and irresistible as defined by the article 1148 of the French Code Civil?

9. CONFIDENTIALITY
As a rule, all information handed by customers to System Plus Consulting are considered as strictly confidential. A non-disclosure agreement can be signed on demand.

10. RESPONSIBILITY LIMITATION
The Buyer is responsible for the use and interpretations he makes of the reports delivered by System Plus Consulting. Consequently, System Plus Consulting responsibility can in no case be called into question for any direct or indirect damage, financial or otherwise, that may result from the use of the results of our analysis or results obtained using one of our costing tools.

11. APPLICABLE LAW
Any dispute that may arise about the interpretation or execution of the current terms and conditions shall be resolved applying the French law.
It the dispute cannot be settled out-of-court, the competent Court will be the Tribunal de Commerce de Nantes.